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ABSTRACT

This document is an instructional module package prepared in objective form for use by an instructor familiar with mathematics as applied to water and wastewater plant operation. Included are objectives, instructor guides, and student handouts. This module is the second of a three level series and addresses ratio and proportions, graphs, total surface area, heat and temperature, metrics, unit loadings and chemical addition. (Author/RH)

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INTERMEDIATE MATHEMATICS

Training Module 1.302.2.77

Prepared for the

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Des Moines, Iowa 50319

by

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September, 1977

SE 023 997

SUMMARY

Module No:

Module Title:

Mathematics for Operators

Approximate Time:

42 Hours

Submodule Titles:

1. Review
2. Ratio & Proportion
3. Graphs
4. Total Surface Area
5. Heat & Temperature
6. Metrics
7. Hydraulic Loading
8. Solid Loading
9. Digesters
10. Chemical Addition
11. Activated Sludge

Overall Objectives:

Upon completion of this module, the learner should be able to use the principles of mathematics of addition, subtraction, multiplication, division and to use specific formulas as applied to water and wastewater treatment technology.

Instructional Aids:

Handout
AV (Overhead transparancy)
Calculators

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept. of Env. Conservation

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association

Class Assignments:

1. Given handouts to be read
2. Given exercise problems to be solved
3. Given evaluation problems to be solved

Module No:

Topic:
Mathematics for Operators

Instructor Notes:

1. Give handouts of each submodule title
2. Allow sufficient time for exercise problems to be done.
3. Review exercise problems.
4. Give evaluation problems.

Instructor Outline:

a. Discuss/demonstrate using the student handout how one calculates using the basic principles of mathematics of addition, subtraction, multiplication and division in

    a. Ratio & Proportion
    b. Metrics
    c. Formulas used in water & wastewater technology

b. Discuss/demonstrate using the student handout how one uses formula as applied to water and wastewater technology in

    a. Making graphs
    b. Heat & Temperature
    c. Hydraulic loading
    d. Solid loading
    e. Digesters
    f. Chemical addition
    g. Activated sludge

Module No:

Module Title:
Mathematics for Operators

Submodule Title:
Review

Approx. Time:
3 hours

Topic:
Review

Objectives:

The learner will demonstrate the ability to determine answers to problems related to:

1. Circumferences
2. Areas
3. Volumes
4. Flow rates
5. Conversion of concentration to pounds

Instructional Aids:

Handout
AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept. of Env. Conservation.

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association.

Class Assignments:

Given 10 exercise problems to be solved.

Module No:	Topic: Review

Instructor Notes:	Instructor Outline:
1. Handout The geometric figures that are most highlighted in Water/Wastewater Technology are: 1. Rectangles 2. Circles 3. Triangles 4. Pyramids (cones) 5. Cylinder 6. Prism 7. Trapizoids	1. Discuss/demonstrate how one calculates typical problems related in: 1. Circumferences 2. Areas 3. Volumes 4. Simple flow rates 5. Conversion of concentration to pounds 2. Give 10 exercise problems

A review of several concepts and mathematical principles would be very helpful.

Let us start by reviewing the use of our pocket calculator.

Find the answer to:

162 - 118 + 123 - 110 - 0.82 + 6.5 - 17 + 4

Try not to use paper and pencil (pen) and maintain a continuous process.

Find the answer to:

1. 1.55 x .05 x 1.9 x .00742 x 896543
2. $\frac{35 \times 35 \times 8.5 \times 3.14 \times 7.48}{2320 \times 60}$

Let us review the principles involved in solving for one unknown.

a. The opposite sign of addition is subtraction.

b. The opposite sign of multiplication is division.

c. To solve for an unknown one has to place the unknown by itself on either side of the equal sign (=) making sure that the sign of unknown is positive (+) or (X).

d. Move all other values to the opposite side of the sign (=) from the unknown.

e. Change all signs of the values that were moved.

f. Perform calculation.

Example: Solve for X

X + 3 = 15

X = 15 - 3

X = 12

Example:

1920 = W x 20 x 8

1920 ÷ 20 ÷ 8 = W

12 = W

or W = 12

Exercise

1. $C = 4 \times L$

   Where $L = 20$ ft.

2. $V = L \times W \times H$

   Where $L = 4$, $W = 3$, $H = 10$

3. $M = \frac{a}{b}$

   When $a = 9$ & $b = 6$

4. $A = (L)^2$

   When $L = 15$

Some formulas that need review that are important in determining the circumferences of geometric figures.

a. Rectangle/square

   $A = 2\ (L + W)$

   L = length and W = width

b. Triangle

   $A = a + b + c$

   Each letter (a, b, c) indicates the length of each side of a triangle.

c. Circle

   $C = 2 \times \pi \times R$ or πD

   When = 3.14 and R is the radius

Exercise

1. What is the area of a rectangle whose dimensions are length, 72 yds. and width 12 yds.
2. A square has a side of 26 ft. What is the circumference of the square.
3. A circle has a radius of 30 ft. What is the circumference.

4. A triangle whose sides are a = 20 ft., b - 15 ft. and c = 25 ft. What is the circumference?

The formulas for areas of

a. Rectangle/square

$A = L \times W$

L = Length and W = Width

b. Circle

$A = \pi \times R^2$ or $.785 \times D^2$

= 3.14, R = Radius, D = Diameter

c. Triangle

$A = \frac{1}{2} (b \times h)$

b = base and h = height

Calculate the areas of

1. A circle whose radius is 30 ft.
2. A triangle with a base of 12 ft. and height of 6 ft.
3. A lagoon whose length is 320 ft. and width of 160 ft.

The formula for volume of

a. Rectangular solid

$V = L \times W \times H$

L = length, W = width, and H = height/depth

b. Cylinder

$V = \pi R^2 \times H$ or $.785 \times D^2 \times H$

= 3.14, R = Radius, H = Height/depth

c. Sphere

$V = 4/3 \pi R^3$

= 3.14, R = Radius

d. Pyramids

1. Rectangular based

   $V = 1/3\ L \times W \times \text{Altitude}$

2. Triangular based

   $V = 1/6\ b \times h \times \text{Altitude}$

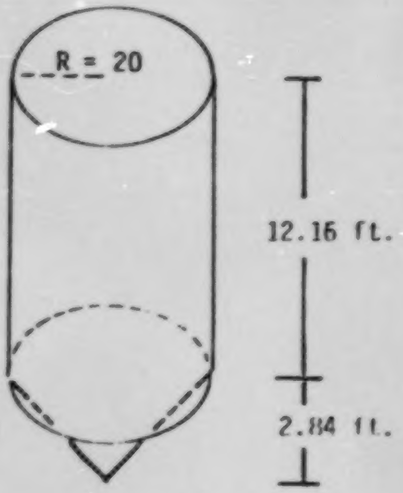
3. Circular based (cone)

   $V = 1/3\ \pi R^2 \times \text{Altitude}$

Remember that in many units in water and wastewater are made up of 2 geometric figures. Ex. water towers, settling basins, digesters.

Exercise

1. What is the volume of a 12 inch water main 3500 ft. long.
2. A settling basin has a length of 60 ft., width of 20 ft., and depth of 8 ft. What is the volume.
3. Find the volume of a figure with the dimensions (See sketch).



Module No:

Module Title:

Mathematics for Operators

Submodule Title:

Ratio and Proportion

Approx. Time:

1 hour

Topic:

Ratio

Objectives:

The learner will demonstrate the ability to calculate problems involving ratios.

Instructional Aids:

Handout
AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept. of Env. Conservation.

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association.

Class Assignments:

1. Read handout
2. Given 10 exercise problems to be solved.

Module No:

Topic: Ratio

Instructor Notes:	Instructor Outline:
1. Give handout	1. Define ratio - the relation between two quantities or numbers which are of the same kind.
The number mentioned first is the first term and the number mentioned second is the second term	a. Discuss/demonstrate how one calculates for the ratio by dividing the first term by the second term.
	b. Given 10 exercise problems.

Ratio

Ratio is the comparing of quantities.

Comparing is done by division.

Division: Comparing by division one divides a quantity by another.

Example

If your flow today is 64,000 gallons and the next day gong flow is 32,000 gallons, then the ratio of 32,000 to 64,000 is:

$\frac{32,000}{64,000}$ = 1/2 times

This means that the flow decreased by 1/2.

In setting up ratio one has to remember what the answer one needs to obtain.

Refer to the example. If one inverted the problem.

$\frac{64,000}{32,000}$ = 2 times

This means that the flow of the previous day was twice the flow of today.

IT IS IMPORTANT THAT UNITS HAVE TO BE THE SAME BEFORE COMPARISON.

Exercise

1. What is the ratio of 8 feet to 2 feet.
2. What is the ratio of 5 ml to 25 ml.
3. If you add to 20 ml of solution enough water to make 1000 ml, what is the dilution ratio.
4. What is the ratio of 24 ft. to 120 ft.
5. If you add to 2 ml of sample enough water to make the solution 25 ml. what is the ratio of dilution.
6. What is the ratio of 6 gallons to 5 cubic feet.
7. If a pump operates for 5 minutes out of each hour, what is the ratio of operating time.
8. What is the ratio of 1 inch to 1 foot.
9. Your plant blue prints indicated that 1/4 inch represents 1 foot. What is the ratio of distance on the plan and the actual distance on the ground.

10. If your plant blue prints indicate a ratio of 1/96 and the distance on the blue prints indicate a measurement of 151 inches, how many feet does 15 inches represent in the plant blue prints if the ratio is 1/96.

Module No:	**Module Title:** Mathematics for Operators
	Submodule Title: Ratio and Proportion
Approx. Time: 1 hour	**Topic:** Proportion

Objectives:

The learner will demonstrate the ability to calculate problems involving proportion.

Instructional Aids:

Handout
AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept. of Env. Conservation.

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association.

Class Assignments:

1. Read handout
2. Given 10 exercise problems to be solved.

Module No:	Topic: Proportion
Instructor Notes:	Instructor Outline:

1. Define proportion - an expression of equality between two ratios.
   - a. Discuss/demonstrate how one determines the proportion of two ratios. The rules to use are:
     1. The product of the means is equal to the product of the extremes.
     2. The product of the extremes divided by either mean gives the mean as quotient.
     3. The product of the means divided by either extreme gives the other extreme as quotient.
   - b. Give 10 exercise problems.

Proportion

A proportion is an indication that two ratios are equal.

Example

6/12 = 9/18

Proportion is expressed as

6:12 = 9:18

This is read as follows

6 is to 12 as 9 is to 18

To make sure that the two ratios are equal set up the expression as follows:

Extremes

6:12 - 9:18

Means

By multiplying the mean and multiplying the extremes the answers should be equal.

Exercise

Are these ratios in proportion

1. 3:36 = 4:48
2. 1:4.3 = 6.7: 28.81
3. 5:20,000 = 15: 60,000

Suppose one of the means was missing

Then

6:12 = ? :18

Since we know that the rule of product of the means = Product of extremes

Than

12 x X = 6 x 18

By solving for X

$$X = \frac{6 \times 18}{12}$$

$$= 9$$

Exercise

1. 3: X = 4:48
2. 5: X = 45:15
3. 6: X = X = 54

If one of the extremes is missing

6:12 = 9: X

Than the product of the means divided by the known extreme gives the other extreme.

$$X = \frac{12 \times 9}{6}$$

$$= .18$$

Exercise

1. X:15 = 5:45
2. 5:4.5 = 9:X
3. X:28000 = 5:156000
4. By adding enough water to 15 gallons chlorine solution of 28000 mg/l to make 156000 gallons compute the new concentration.

Module No:	Module Title: Mathematics for Operators
Approx. Time:	Submodule Title: Ratio and Proportion
	EVALUATION

Objectives:

The learner will demonstrate the ability to determine correctly the answers to 8 out of 10 problems related to ratio and proportion in water and wastewater technology.

1. 5.8 = 8 = 29.0 = 40 T F

2. 23:15 = 46 = 34 T F

3. 4:36 x = 81

   a. 1.7

   b. 729

   c. 9

   d. .56

4. x = 90 = 10:5

   a. 1.8

   b. 45

   c. 180

   d. .55

5. What is the length of water main to be purchased if the blue print indicates 26 inches and the ratio is ¼" to 1 foot.

   a. 6.5 ft.

   b. 104 ft.

   c. 1248 ft.

6. What is the ratio of dilution if you add 5 ml. of sample to 20 ml. of water.

   a. 1/4

   b. 1/5

   c. 5

   d. 4

7. What is the new concentration of a 5 gallon 45,000 mg/l fluoride solution when added to 195 gallons of water.

   a. 0.0217

   b. 1125

   c. 46.15

   d. 1.7

8. A water plant has a raw flow of 600,000 gallons from a surface reservoir and a flow of 200,000 gallons from 2 wells. What is the ratio of well water to survace water.

   a. 1/3

   b. 3

   c. 1/4

   d. 4

9. The total flow to a plant is 1.8 MGD. If .45 MGD of the total flow is recirculated what is the ratio of recirculated to the total flow.

   a. 1/3

   b. 3

   c. 6

   d. 1/6

10. A ratio of recirculation in a plant is set at 2/5 of the flow into the plant. What is the volume of recirculation if the flow into the plant is 268,000 gallons.

    a. 6700 gallons

    b. 107200 gallons

    c. 67000 gallons

    d. 53600 gallons

Module No:	Topic: EVALUATION

Instructor Notes:	Instructor Outline:
1. Handout Answers 1. T 2. F 3. C 4. C 5. C 6. B 7. B 8. A 9. D 10. B	1. Give 10 evaluation problems.

Module No:

Module Title: Mathematics for Operators

Submodule Title: Graph

Approx. Time: 2 hours

Topic: Graphing

Objectives:

1. The learner will demonstrate the ability to graph curves or line graph sets of interrelated values onto graph paper.
2. The learner will demonstrate the ability to illustrate values in simple bar graph.

Instructional Aids:

Handout
AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept. of Env. Conservation.

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association.

Class Assignments:

1. Read handout
2. Given 2 exercise problems to be graphed.

Module No:	Topic: Graphing

Instructor Notes:	Instructor Outline:
1. Handout	1. Discuss/demonstrate how one uses graph paper to plot interrelated values.
2. Emphasis that several graphs can be plotted on the same graph paper to show the relationship between different parameters. Ex. BOD & SS, Flow, Total Solids or Flow, Rain	2. Discuss/demonstrate how one develops bar graph.
3. The axis of abiscissas (the horizontal axis) usually indicates time (days, hours).	3. Give Exercise problems to be graphed.

Graphs

Graphs are visual methods of presenting relations of quantities to each other.

Graphs also tend to show a trend in parameters. That is one can see alot easier if, say, the BOD influent is increasing or decreasing.

Graphs are presented in many forms but the two types most used is

A. Line graphs or curves

B. Bar graphs

1. Line graphs

   To construct a line graph one needs to have:

   a. Graph paper

   b. Data needed to graph

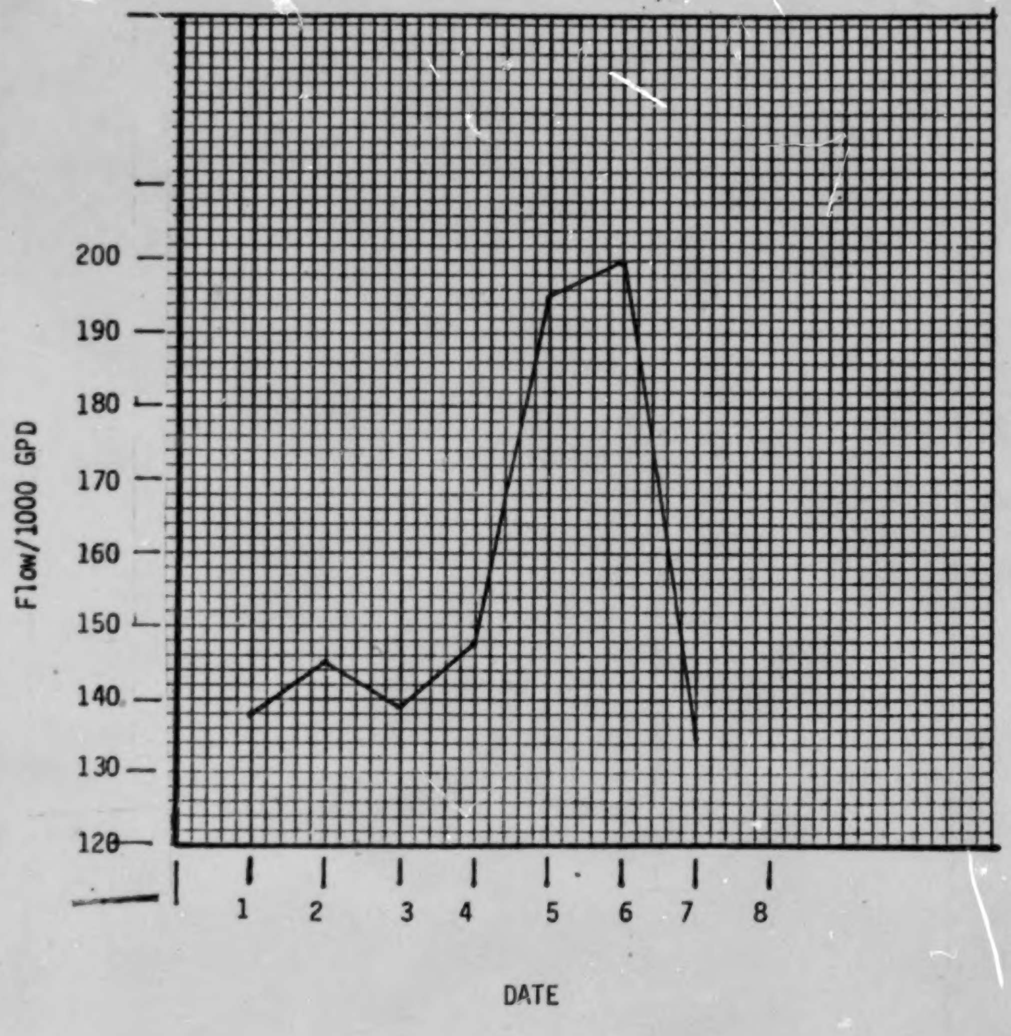
   To construct a graph choose a horizontal line called the axis of abscissas (X) and a vertical line called the asis of ordinate (Y). Where line (X) and (Y) cross the point is called point of origin (O). The spaces on the graph paper are assigned values according to the data supplied. It is evident then that these values will vary greatly and must be chosen to suit the requirement of the problem with.

   Example

   Construct a graph from the data available:

Date	Flow/1000 GPD
1	138
2	145
3	129
4	148
5	195
6	200
7	135

2


Flow/1000 GPD
200
190
180
170
160
150
140
130
120
1
2
3
4
5
6
7
8
DATE

Solution

On your graph paper mark below (X) axis, the dates make sure that they are spaced out evenly. (zero, 1, 2, 3, 4, 5 on your (Y) axis.) Mark from zero to 50 and space them out evenly. (See Graph).

Using the data provided find the column that represents the Date 1.

Move up the column and find the horizontal line that represents 138.

Place a dot at that point.

Proceed to the column that represents the Date 2.

Move up the column and find the horizontal line that represents 145.

Place a dot at that point.

By proceeding through all the dates your graph will be full of dots.

Now start with the dot that represents Date 1, Flow 138, and connect to dot representing Dot 2, Flow 145, and so on.

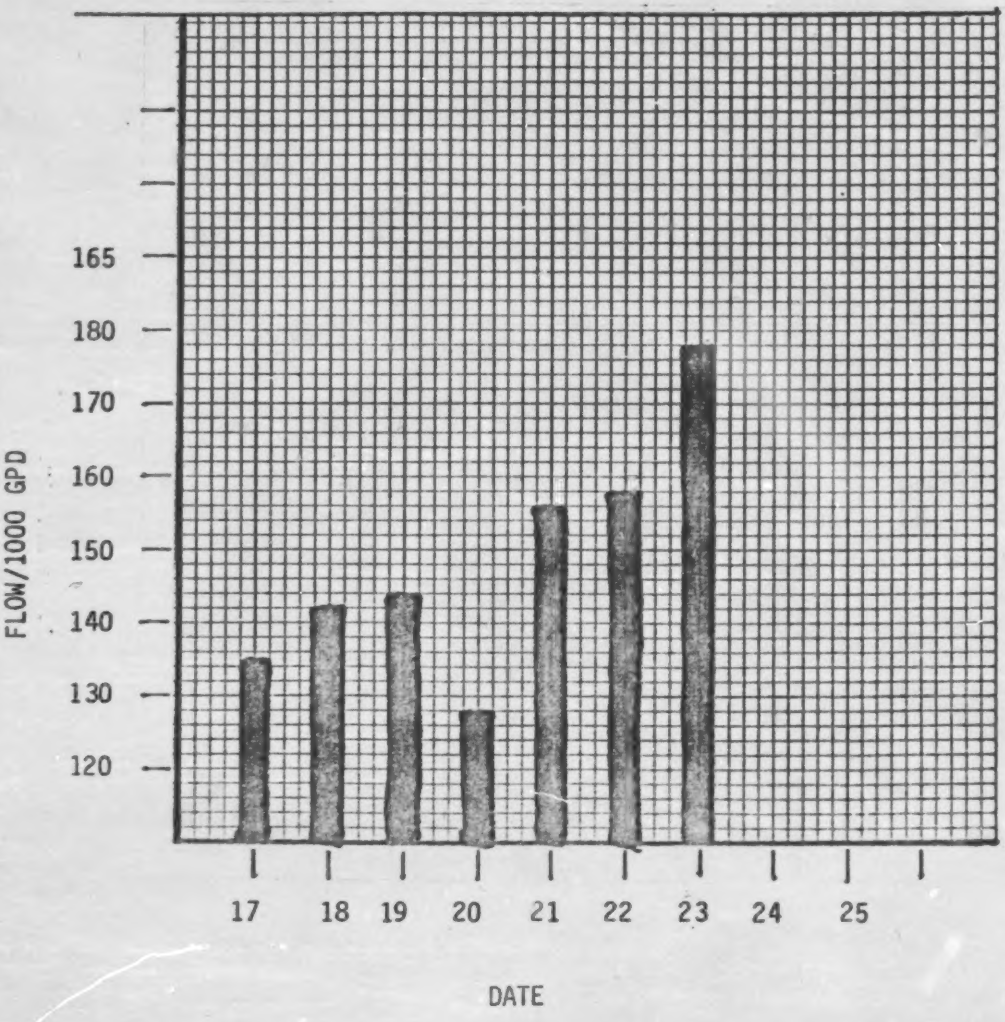
After connecting all the dots one will notice a figure. This is called a line graph.

If one maintains a graph on a continuous basis, one may be able to alter a lot of data, project plant operation.

Exercise

Chart these data.

Time	GPM	Time	GPM	Time	GPM
12	2200	5	1200	10	6400
1 a.m.	2150	6	2000	11	7000
2	1800	7	3500	12 noon	6600
3	1400	8	5000	11 p.m.	6400
4	1300	9	6000	2	6300


FLOW/1000 GPD
165
180
170
160
150
140
130
120
17
18
19
20
21
22
23
24
25
DATE

Time	GPM	Time	GPM
3	6400	8	8400
4	6400	9	5000
5	6700	10	3200
6	7400	11	2800
7	9200		

2. Bar Graphs

Drawing bar graphs is much like drawing line graphs. Lay out a horizontal axis and a vertical axis and mark them according to the data furnished. Draw bars of a length that will correspond to the amounts involved.

Date	Flow/1000 GPD
17	135
18	142
19	141
20	128
21	156
22	158
23	178

Exercise

Time	GPM	Time	GPM
12 p.m.	933	1 p.m.	2130
1 a.m.	866	2	2170
2	866	3	2330
3	600	4	2300
4	634	5	2740
5	1000	6	3070
6	1330	7	3330

Time	GPM	Time	GPM
7	1830	8	2670
8	2570	9	2000
9	2500	10	1330
10	2140	11	1170
11	7080		
12	2170		

Module No:

Module Title:
Mathemtaics for Operators

Submodule Title:
Graphs

Approx. Time:
1 hour

Topic:
Meaning of Curves or line graphs

Objectives:

The learner will demonstrate the ability to obtain usable information from curves or line graphs illustrated.

Instructional Aids:

Handout
AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept. of Env. Conservation.

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association.

Class Assignments:

1. Read handout
2. Given 2 graphs as exercise for the obtaining of various information as indicated by instruction.

Module No:	Topic: Meaning of Curves or Line Graphs

Instructor Notes:	Instructor Outline:
1. Handout	1. Discuss/demonstrate how one interprets available information from curves or line graphs. 2. Give two graphs as exercises to be interpreted.

Meaning of curves or line graph

Most graphs are developed with the ability to obtain information. Areas where graphs are used to obtain information that is useful in water or wastewater technology.

a. Pump performance

b. Laboratory analysis

(absorbance or transmittance)

To be able to "read" a graph one needs to have:

1. A graph

2. A value on either the (X) axis or (Y) axis.

See figure 1

A graph having an (X) axis indicating concentration and a (Y) axis indicating absorbance.

If one knows the absorbance obtained from lab tests than by joining the number on the (Y) axis to the curve with a line paralleled to the (X) axis.

The point where the line crosses the curve, join that point with the (X) axis with a line paralleled to the (Y) axis.

Example

Using the graph in Figure I, find the concentration if the absorbance is

1. 0.21

Exercise

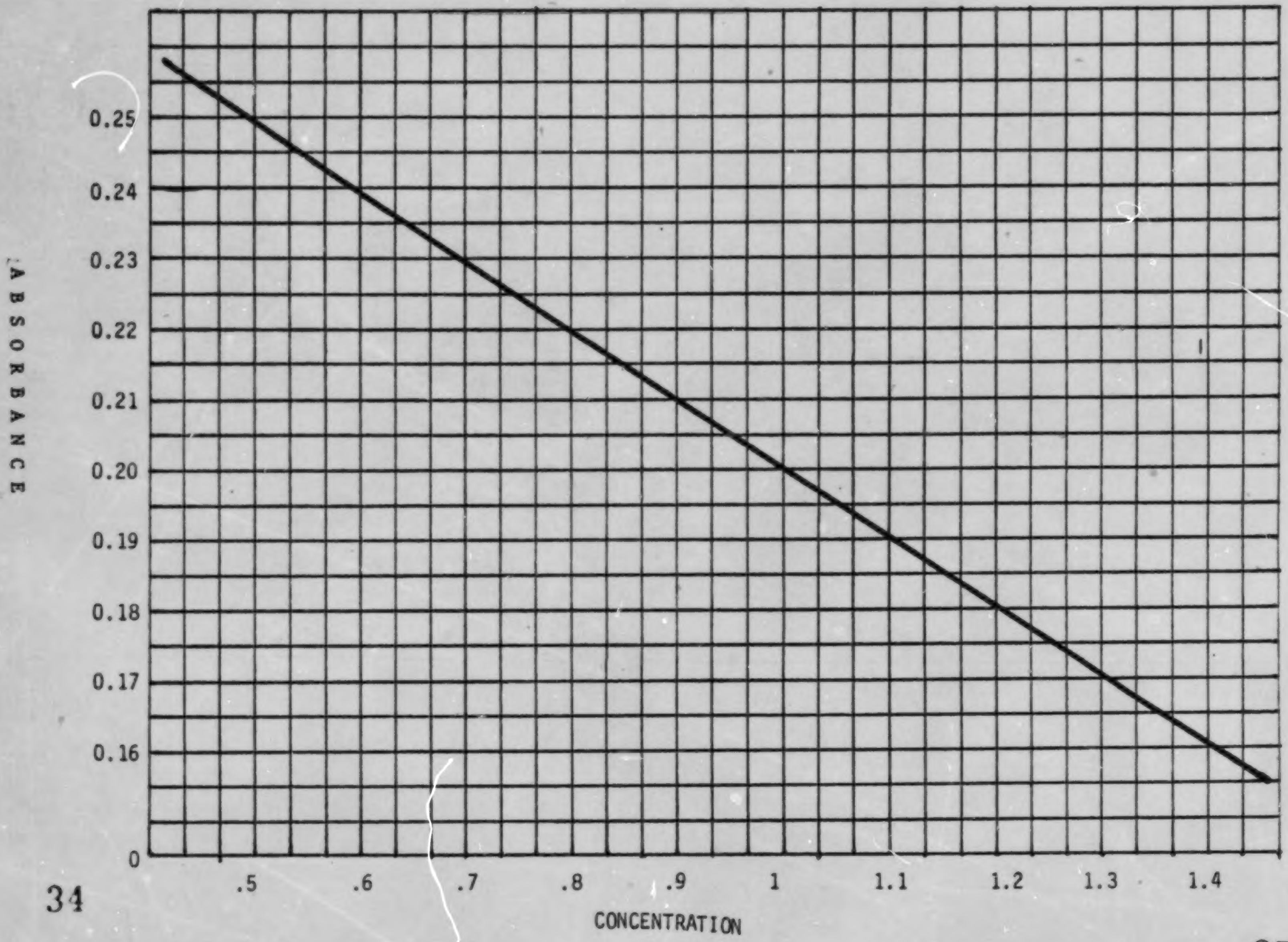
1. 0.185

2. 0.2

3. 0.225

4. 0.195

FIGURE I



ABSORBANCE
0.25
0.24
0.23
0.22
0.21
0.20
0.19
0.18
0.17
0.16
0
.5
.6
.7
.8
.9
1
1.1
1.2
1.3
1.4
CONCENTRATION

Module No:

Module Title: Mathematics for Operators

Submodule Title: Graphs

Approx. Time: 1 hour

EVALUATION

Objectives:

1. Given a set of data, the learner will demonstrate the ability to properly graph the data.
2. Given a graph the learner will demonstrate the ability to obtain values to answer correctly to four questions.

1. In the determination of fluoride the three standards tested provided the following results:

conc.	Absorbance
0.8 mg/l	0.23
1.0 mg/l	0.21
1.2 mg/l	0.19

Determine after plotting a graph the concentration of a sample of fluoride if the absorbance is Show your work on graph provided.

2. Using the graph marked PUMP CURVE

   a. What is the approximate GPM if the head is 80 ft.

      1. 80 GPM
      2. 10 GPM
      3. 480 GPM
      4. 456 GPM

3. This pump is pumping against a head of 140 ft. How many maximum gallons per minute will it deliver?

   a. 264

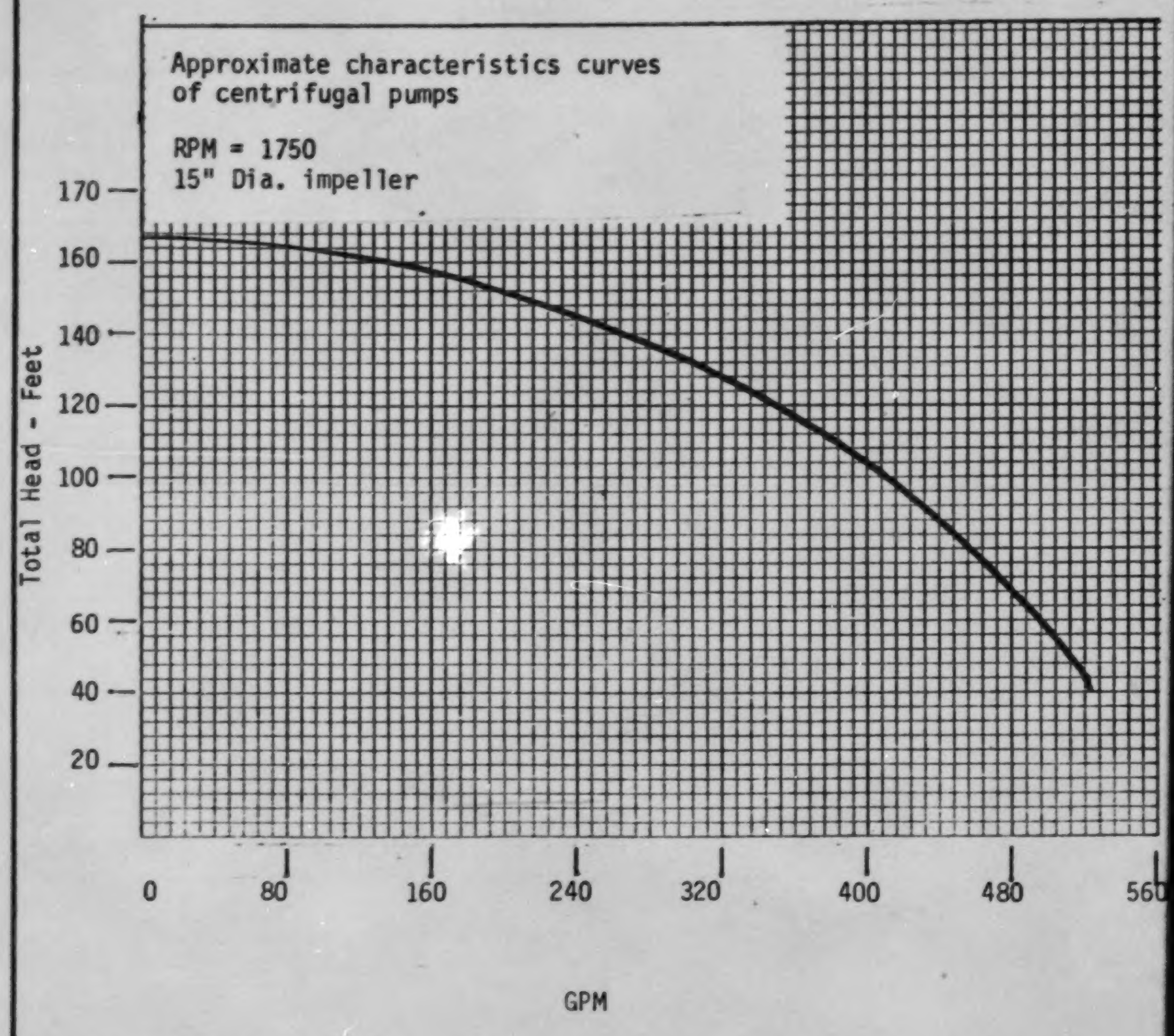
   b. 24p

   c. 140

   d. 400

4. At what maximum head in feet will this pump deliver 320 GPM?
   a. 127 ft.
   b. 140 ft.
   c. 200 ft.
   d. 30 ft.
5. This pump will deliver 560 GPM's water at a head (in feet) of 170 ft.
   a. True
   b. False

PUMP CURVE


Approximate characteristics curves of centrifugal pumps
RPM = 1750
15" Dia. impeller
Total Head - Feet
170
160
140
120
100
80
60
40
20
0
80
160
240
320
400
480
560
GPM

Module No:	Topic: EVALUATION

Instructor Notes:	Instructor Outline:
Answers 1. d 2. a 3. a 4. b	1. Give a set of values to be graphed. 2. Give a graph to obtain values.

Module No:

Module Title:
Mathematics for Operators

Submodule Title:
Total Surface Area TSA

Approx. Time:
½ hr.

Topic:
Rectangular Solid

Objectives:
The learner will demonstrate the ability to determine the total surface area of a rectangular solid.

Instructional Aids:

Handout

AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations*, N. Y. Dept. of Env. Conservation

College Arithmetic, 2nd Edition, W. I. Layton, Wiley & Sons.

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association

Class Assignments:

Given 4 exercise problems to be solved

Module No:

Topic:
Rectangular Solids

Instructor Notes:

1. Handout
   - a. Emphasis that the unit values of TSA is in square ft. or square yds. etc.
   - b. The unit values of the length, width, and height should be of the same unit i.e. ft. or yds. or inches etc.

Instructor Outline:

1. Discuss/demonstrate how one calculates the total surface area of a rectangular solid using the formula

   $TSA = 2 (L \times W) + 2 (L \times H) + 2 (W \times H)$

   TSA = Total surface area

   L = Length of unit

   W = Width of unit

   H = Height/depth of unit

2. Give 4 exercise problems

Rectangular Solids

The total surface area (TSA) of a rectangular solid is the sum of all six areas of that solid.

Formula

The TSA of a rectangular solid is equal to

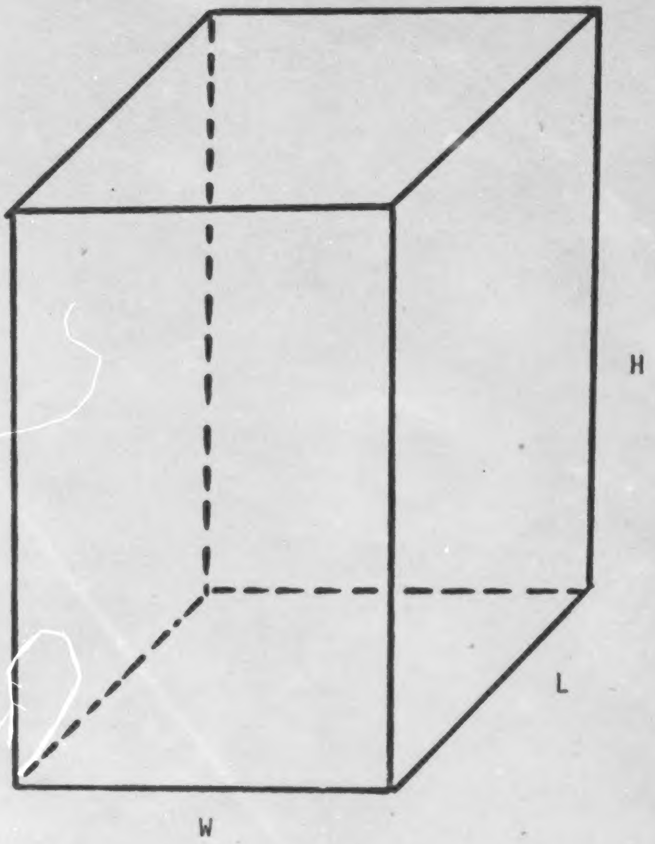
TSA = 2 x L x W + 2 x L x H + 2 x W x H

TSA = Total surface area

L = Length

W = Width

H = Height or depth



Example

A rectangular solid has a length of 20 ft., a width of 10 ft. and a depth of 8 ft. What is the total surface area?

Solution

TSA = 2 x L x W + 2 x L x H + 2 x W x H

= 2 x 20 x 10 + 2 x 20 x 8 + 2 x 10 x 8

= 400 + 320 + 160

= 880 sq. ft.

Remember that this is an area and the unit value has to be square.

Exercise

1. A rectangular shaped clear well has to be painted the dimensions of length 40 ft., width 12 ft. and depth 12 ft. What is the total surface area of the clear well?
2. A cube has the dimensions of 15 ft. What is the total surface area?
3. A rectangular shaped room needs painting. The length is 30 ft., width 13 ft., height 9 ft. What is the total surface area of the room?
4. A storage tank rectangular in shape with a length of 60 ft., width 16 ft. and depth of 12 ft. needs painting. What is the total surface area.

Module No:	Module Title: Mathematics for Operators
	Submodule Title: Total Surface Areas (TSA)
Approx. Time: ½ hr.	Topic: Cylinder

Objectives:

The learner will demonstrate the ability to determine the total surface area of a cylinder.

Instructional Aids:

Handout

AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept. of Env. Conservation

College Arithmetic, 2nd Edition, W. I. Layton, Wiley & Sons.

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association

Class Assignments:

Given 4 exercise problems to be solved

Module No:	Topic: Cylinder

Instructor Notes:	Instructor Outline:
1. Handout a. Emphasis that the unit values of TSA is in square ft. or square yds. etc. b. The unit values of radius and height of the cylinder should be of the same unit, i.e. ft. or yds. or inches.	1. Discuss/demonstrate how one calculates the total surface area of a cylinder using the formula $TSA = 2 (\pi R^2) + (2\pi R \times H)$ or $TSA = 2 (.785 \times D^2) + (\pi D \times H)$ TSA = Total surface area $\pi = 3.14$ R = Radius of circle H = Height of cylinder D = Diameter of circle 2. Give 4 exercise problems

Cylinder

The total surface area of a cylinder is composed of

a. The top and bottom of the cylinder.

b. The side of the cylinder.

Formula

The formula used to determine the total surface area of a cylinder is

$TSA = 2 \times \pi \times R^2 + 2 \times \pi \times R \times H$

TSA = Total surface area

$\pi = 3.14$

R = Radius of circle

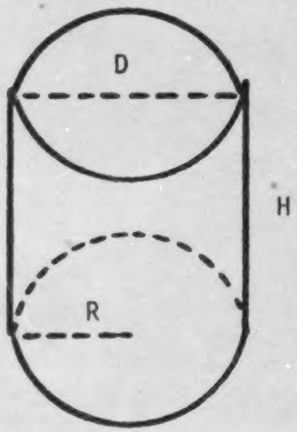
H = Height of cylinder

Notice that R^2 = Area of a circle and

$2\pi R$ = Circumference of a circle

Another formula could be used:

$TSA = 2\ (.785 \times D^2) + \pi \times D \times H$



Example

Find the total surface area of a cylinder if the radius is 30 ft. and the height is 8 ft.

Solution

$$TSA = 2 \times \pi \times R^2 + 2 \times \pi \times R \times H$$

$$= 2 \times 3.14 \times (30)^2 + 2 \times 3.14 \times 30 \times 8$$

$$= 5652 + 1507.2$$

$$= 7159.2 \text{ sq. ft.}$$

Remember that this is area and it's unit value is square.

Exercise

1. A cylindrical storage tank is 50 ft. in diameter and 20 ft. in height. What is the total surface area of the tank?
2. A digester has the dimensions of diameter 35 ft. and depth of 14 ft. What is the total surface area of the digester?
3. Calculate the total surface area of a cylindrical tank. Radius 16 ft. and depth 5 ft.
4. A steel drum is to be painted. What is the total surface area of the drum if the diameter is 36 inches and the height is 4 feet.

Module No:	**Module Title:** Mathematics for Operators
	Submodule Title: Total Surface Area (TSA)
Approx. Time: 1 hr.	**Topic:** Pyramids

Objectives:

The learner will demonstrate the ability to determine the total surface area (TSA) of

1. Triangular based pyramid
2. Rectangular based pyramid
3. Circular based pyramid (cone)

Instructional Aids:

Handout

AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept. of Env. Conservation

College Arithmetic, 2nd Edition, W. I. Layton, Wiley & Sons

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association

Class Assignments:

Given 4 exercise problems to be solved

Module No:	Topic: Pyramid

Instructor Notes:	Instructor Outline:
1. Handout a. Emphasis that the unit values of TSA is in square ft. or square yds. etc. b. The unit values of the base (b), height (h), circumference (a + b + c) slant height should be of the same unit i.e. ft. or yds. or inches etc. c. Emphasis the difference between height and slant height	1. Discuss/demonstrate how one calculates the total surface area of a triangular based pyramid using the formula $TSA = (\frac{1}{2} b \times h) + \frac{(a + b + c)}{2}$ slant height TSA = Total surface area b = Base of triangle h = Height of triangle (a + b + c) = Circumference of triangle Slant height = Slant height of pyramid
2. Handout a. Emphasis that the unit values of TSA is in square ft. or square yds. etc. b. The unit values of the length (L) width (W) and slant height should be of the same unit i.e. ft. or yds. or inches c. Emphasis the difference between height and slant height	2. Discuss/demonstrate how one calculates the total surface area of a rectangular based pyramid using the formula $TSA = (L \times W) + (L + W)$ slant height TSA = Total surface area L = Length of rectangle W = Width of rectangle Slant height of pyramid

Module No:	Topic: Pyramid
Instructor Notes:	**Instructor Outline:**
3. Handout a. Emphasis that the unit values of TSA is in square ft. or square yds. b. The unit values of the radius or diameter and slant height should be of the same unit i.e. ft. or yds. or inches c. Emphasis the difference between height and slant height	3. Discuss/demonstrate how one calculates the total surface area of a circular based pyramid (cone) using the formula TSA = $(\pi R^2) + (\pi R)$ slant height or TSA = $(.785 \times D^2) + (\frac{\pi D}{2})$ Slant height TSA = Total surface area $\pi = 3.14$ R = Radius of circle D = Diameter of circle Sland height = Slant height of cone

Pyramids

The total surface area of pyramids is determined according to the shape of the pyramid,

a. Triangular based

b. Rectangular based

c. Circular based (cone)

And the slant height of the pyramid.

The definition of slant height (SH) is the shortest line from the apex of the pyramid (i.e. tip) to the edge of the pyramid.

NOTE: The corners of a triangle or rectangle are NOT the edge of the pyramid.

Triangular based pyramid

The formula used to determine the total surface area of a triangular based pyramid is:

TSA = $\frac{1}{2}$ (b x h) + $\frac{1}{2}$ (a + b + c) x slant height

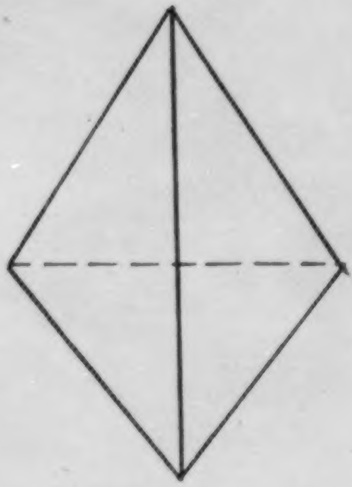
TSA = Total surface area

b = Base of the triangle

h = Height of the triangle

(a + b + c) = Circumference of the triangle

Slant height = Slant height of pyramid



Example

Calculate the total surface area of a triangular based pyramid if the sides of the triangle have dimensions of:

a = 30 ft.

b = 30 ft.

c = 30 ft.

h = 25.98 ft.

slant height = 35 ft.

Solution

TSA = ½ (b x h) + ½ (a + b + c) slant height

= ½ x 30 x 25.98 + ½ (30 + 30 + 30) 35

= 389.7 sq. ft. 1575 sq. ft.

= 1964.7 sq. ft.

Exercise

What is the total surface area of a rectangular based pyramid when

a = 20

b = 20

c = 20

h = 17.32

slant height = 30

Rectangular based pyramid

The formula to use to determine the total surface area of a rectangular based pyramid is:

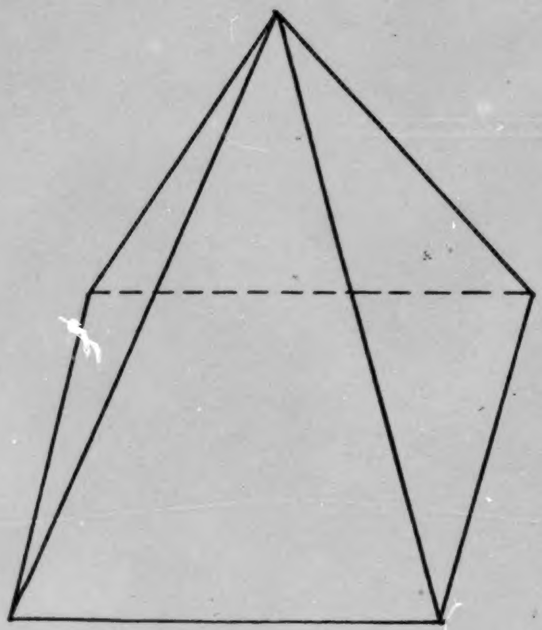
TSA = (L x W) + (L + W) slant height

TSA = Total surface area

L = Length of rectangle

W = Width of rectangle

Slant height = Slant height of pyramid



Example

A rectangular based pyramid has the dimensions of length 40 ft., width 40 ft., and a slant height of 19 ft.

Solution

TSA = (L x W) + (L + W) slant height

= (40 x 20) + (40 + 40) 19 ft.

= 800 + 80 x 19

= 800 + 1520

= 2320

Exercise

A rectangular based rectangle has the dimensions of slant height of 3.2 ft., length of 5 ft. and width of 5 ft. What is the total surface area.

Circular based pyramid (cone)

The formula used to determine the total surface area of a circular based pyramid (cone) is:

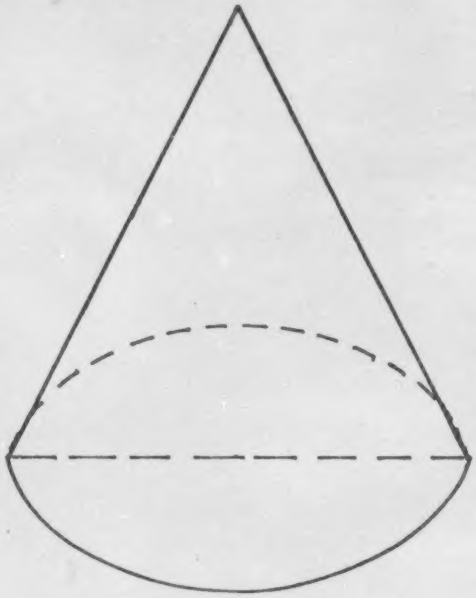
TSA = $(\pi \times R^2) + (\pi \times R \times \text{slant height})$

TSA = Total surface area

= 3.14

R = Radius of circle

Slant height - slant height of pyramid



Example

A cone has a radius of 25 ft. and slant height of 25.5 ft. Calculate the total surface area.

Solution

TSA = $(\pi \times R^2) + (\pi \times R \times \text{slant height})$

= $3.14 \times 25 \times 25 + (3.14 \times 25 \times 25.5)$

= $1968.75 + 2001.75$

= 3970.5 sq. ft.

Exercise

1. What is the total surface area of a cone that has a radius of 50 ft. and a slant height of 51 ft.

2. Calculate the total surface area of a circular based pyramid if the diameter of circle is 60 ft. and the slant height is 33 ft.

Module No:	Module Title: Mathematics for Operators
	Submodule Title: Total Surface Area (TSA)
Approx. Time: ½ hr.	Topic: Sphere

Objectives:

The learner will demonstrate the ability to determine the total surface area of a sphere.

Instructional Aids:

Handout

AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept. of Env. Conservation

College Arithmetic, 2nd Edition, W. I. Layton, Wiley & Sons

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association

Class Assignments:

Give 4 exercise problems to be solved

Module No:	Topic: Sphere

Instructor Notes:	Instructor Outline:
1. Handout a. Emphasis that the unit values of TSA is in square ft. or square yds. etc.	1. Discuss/demonstrate how one calculates the total surface area of a sphere using the formula $TSA = 4 \times \pi \times R^2$ TSA = Total surface area $\pi = 3.14$ R = Radius of sphere

Spheres

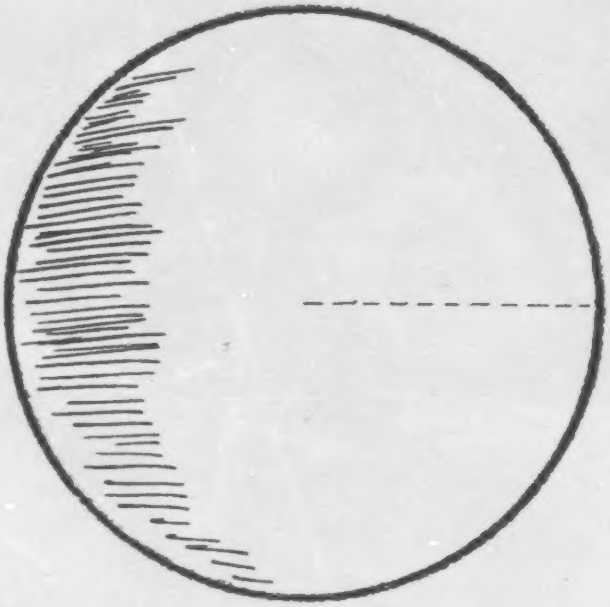
The total surface area of the sphere is determined by using the formula

$TSA = 4 \times \pi \times R^2$

TSA = Total surface area

= 3.14

R = Radius of the sphere



Example

A sphere has a radius of 30 ft. What is the total surface area.

Solution

$TSA = 4 \times \pi \times R^2$

$= 4 \times 3.14 \times 30 \times 30$

$= 11304$ sq. ft.

Exercise

1. A spherical gas storage tank with a diameter of 100 ft. needs painting. What is the total surface area?

2. What is the total surface area of a sphere full of water if the radius is 25 ft.

Module No:	Module Title: Mathematics for Operators
Approx. Time: 1 hour	Submodule Title: Total Surface Area
	EVALUATION

Objectives:

The learner will demonstrate the ability to determine correctly the answers to 8 out of 10 questions related to total surface areas of:

1. Rectangular solids
2. Cylinders
3. Pyramids
4. Spheres

1. What is the total surface area inside a cylindrical digester if the radius is 18 ft. and the depth is 15 ft.

   a. 2712.96 sq. ft.

   b. 15260.4 sq. ft.

   c. 30520.8 sq. ft.

   d. 3730.32 sq. ft.

2. A spherical water tower needs painting. What is the total surface area if the diameter of the sphere is 45 ft.

   a. 565.2 sq. ft.

   b. 6358.5 sq. ft.

   c. 25434.0 sq. ft.

   d. 3179.25 sq. ft.

3. A rectangular clear well has a length of 60 ft., width 30 ft. and depth of 12 ft. What is the total surface area?

   a. 5760 sq. ft.

   b. 10800 sq. ft.

   c. 4680 sq. ft.

   d. 14200 sq. ft.

4. A cube has the dimensions of 32 meters. What is the total surface area?

   a. 32768.0 sq. meters

   b. 6144 sq. meters

   c. 40960 sq. meters

   d. 3072 sq. meters

5. A spherical gas storage tank has a radius of 12 ft. What is the total surface area?

   a. 7234.56 sq. ft.

   b. 1356.48 sq. ft.

   c. 452.16 sq. ft.

   d. 1808.64 sq. ft.

6. A cone has a radius of 12 ft. and a slant height of 15 ft. What is the total surface area?

   a. 1017.36 sq. ft.

   b. 2260.8 sq. ft.

   c. 6782.41. sq. ft.

   d. 194.2 sq. ft.

7. A rectangular based pyramid has the dimensions of length 30 ft., width 30 ft., and slant height of 33 ft. What is the total surface area?

   a. 29700 sq. ft.

   b. 2880 sq. ft.

   c. 3870 sq. ft.

   d. 7425 sq. ft.

8. A rectangular building has a length of 110 ft., width 30 ft. and depth 25 ft. What is the total surface area?

   a. 6800 sq. ft.

   b. 82500 sq. ft.

   c. 19800 sq. ft.

   d. 13600 sq. ft.

9. A sphere with a radius of 28 ft. has a total surface area of:

   a. 4923.52 sq. ft.

   b. 2461.76 sq. ft.

   c. 9847.04 sq. ft.

   d. 3282.34 sq. ft.

10. A cone has a radius of 20 ft. and slant weight of 25 ft. What is the total surface area?

    a. 2826. sq. ft.

    b. 31400 sq. ft.

    c. 7850. sq. ft.

    d. 1570 sq. ft.

Module No:

Evaluation

Instructor Notes:	Instructor Outline:
1. Handout	1. Give 10 evaluation problems
Ans.	
1. d	
2. b	
3. a	
4. b	
5. d	
6. a	
7. b	
8. c	
9. c	
10. a	

Module No:	Module Title: Mathematics for Operators
	Submodule Title: Heat and Temperature
Approx. Time: 1 hour	Topic: Temperature

Objectives:

The learner will demonstrate the ability to convert:

1. Degrees Fahernheit to degrees Celcius
2. Degrees Celcius to degrees Fahrenheit

Instructional Aids:

Handout

AV (overhead transparency)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Physics for Career Education, Ewer, Nelson, Schurter, McFadden, Prentice Hall Inc. N. J.

Class Assignments:

Given 8 exercise problems to be solved.

Module No:

Topic:
Temperature

Instructor Notes:

1. Handout

Instructor Outline:

1. Discuss/demonstrate how one converts ^{o}F to ^{o}C using the formula:

   $$^{o}C = \frac{^{o}F - 32}{1.8}$$

   ^{o}C = Degrees Celcius

   ^{o}F = Degrees Fahrenheit

2. Give 4 exercise problems

3. Discuss/demonstrate how one converts ^{o}C to ^{o}F using the formula:

   $$^{o}F = (1.8 \times {^{o}C}) + 32$$

   ^{o}F = Degrees Fahrenheit

4. Give 4 exercise problems

Conversion of Degrees Fahrenheit to Degrees Celcius

To convert °F to °C one can use the formula

$$C = \frac{{}^{o}F - 32}{1.8}$$

Where °C = Degrees celcius

°F = Degrees fahrenheit

Example: Change 72°F to °C

Solution

$$ {}^{o}C = \frac{{}^{o}F = 32}{1.8}$$

$$= \frac{72 - 32}{1.8}$$

$$= \frac{40}{1.8}$$

$$= 22.22\ {}^{o}C$$

Exercise

Change to °C

1. 68° F
2. 118° F
3. 30° F
4. -5° F

Conversion of Degrees Celcius to Degrees Fahrenheit

To convert °C to °F one can use the formula

$${}^{o}F = (1.8 \times {}^{o}C) + 32$$

Example

Change 40° C to ° F

Solution

$$
\begin{aligned}
{}^{o}F &= (1.8 \times {}^{o}C) + 32 \\
&= (1.8 \times 40) + 32 \\
&= 72 + 32 \\
&= 104^{o}\ F
\end{aligned}
$$

Exercise: Change ^{o}C to ^{o}F

1. 20^{o} C
2. 48^{o} C
3. 100^{o} C
4. -5^{o} C

Module No:	Module Title: Mathematics for Operators
	Submodule Title: Heat and Temperature
Approx. Time: 1 hour	Topic: British Thermal Units (BTU's)

Objectives:

The learner will demonstrate the ability to determine the amount of heat (BTU) needed to heat a specific amount (Lbs.) of water.

Instructional Aids:

Handout

AV (overhead transparency)

Instructional Approach:
Discussion
Demonstration
Exercise

References:

Physics for Career Education, Ewer, Nelson, Schurter, McFadden, Prentice Hall Inc. N. J.

Class Assignments:

Give 6 exercise problems to be solved.

Module No:	Topic: BTU's

Instructor Notes:	Instructor Outline:
1. Handout	1. Define BTU
Emphasis DT DT being the change in temperature in °F	2. Discuss/demonstrate how one calculates the amount of heat (BTU's) needed to heat a specific weight (Lbs.) of water to a required temperature. The formula to use is BTU = DT x weight of water BTU = British Thermal Unit DT = The change in temperature in °F Weight of water = Weight of water in Lbs.
	3. Give 4 exercise problems.

BTU's

The definition of BTU (British Thermal Units) is that it is a measure of heat (energy) and that if a person heats a lb. of water and raises the temperature 1° F, the energy needed is 1 BTU.

Formula

The formula to use to calculate the BTU's required to heat water or sludge etc. is:

BTU = DT x weight in water

BTU = British Thermal Units

DT = Change in temperature in °F

Weight of water = Weight of water in lbs.

Example

How many BTU's is needed to heat 40 lbs. of water if the water temperature is 40°F and it is needed at 125° F.

Solution

BTU = DT x Wt. of water

DT = Needed temp. - Starting temp.

= 125° F - 40° F

= 85° F

Therefore:

BTU = 85° F x 40 lbs.

= 3400 BTU's

Exercise

1. How many BTU's is necessary to heat the temperature of 600 lbs. of water 60 degrees (Fahrenheit degrees).

2. Water supplied from the main is 52° F and the process needs 140° F water temperature. How many BTU's is needed if the volume of water used weighs 650 lbs.

3. A tank has a volume of 128000 gallons. If the tank lost a total of 2° F how many BTU's is needed to restore the original temperature.

4. A cylindrical tank has the dimensions of 30 ft. diameter and 12 ft. height. It is filled with water that has a temperature of 56° F. How many BTU's are needed to raise the temperature to 130° F.

Module No:	Module Title: Mathematics for Operators
	Submodule Title: Heat and Temperature
Approx. Time: 1 hour	Topic: Calories

Objectives:

The learner will demonstrate the ability to determine the amount of heat (calories) needed to heat a specific amount (Lbs.) of water

Instructional Aids:

Handout

AV (overhead transparency)

Instructional Approach:
Discussion
Demonstration
Exercise

References:

Physics for Career Education, Ewer, Nelson, Schurter, McFadden, Prentice Hall Inc. N. J.

Class Assignments:

Give 6 exercise problems to be solved.

Module No:

Topic: Calories

Instructor Notes:	Instructor Outline:
1. Handout	1. Define calories
2. Emphasis DT DT being the change in temperature in ^{o}C.	2. Discuss/demonstrate how one calculates the amount of heat (calories) needed to heat a specific weight (Lbs.) of water to a required temperature. The formula to use is: Calories = DT x Weight of water Calories = The amount of heat DT = The change in temperature in ^{o}C. Weight of water = Weight of water in grams
	3. Give 4 exercise problems.

Calories

The definition of calories (a measure of heat) is that the energy of heat needed to raise the temperature of 1 gram 1° C.

Formula

Calories = DT x Wt. of water

DT = The change in temperature in degrees celcius

Wt. of water = Weight of water in grams

Example

The temperature of a 30 gram weight of water is raised 30 degrees. What is the amount of calories needed?

Solution

Calories = DT x Wt. of water

= 30 x 30

= 900

Exercise

1. The starting temperature of water is 10° C. The water temp. needed is 80° C. If the weight of the water is 1000 grams, what is the calories needed?

2. In Problem 1, if the weight of the water is 1000 kilograms what is the calories needed.

3. A water tank has the dimensions of 30 meters x 30 meters x 15 meters. The temperature of the water is raised 20 delcius degrees. How many calories did the water absorb. Exclude any heat loss.

4. A water temperature was changed from 54° C - 64° C. If 627000 calories were used what was the weight of the water (assume the water absorbed all the heat).

Module No:	Module Title: Mathematics for Operators
	Submodule Title: Heat and Temperature
Approx. Time: 1 hour	EVALUATION

Objectives:

The learner will demonstrate the ability to determine correctly the answers to 8 out of 10 problems related to:

1. Conversion of °F to °C
2. Conversion of °C to °F
3. The amount of heat needed to heat a specific volume of water either in BTU's or calories.

1. Change 20° C to ° F
   a. 43.11° F
   b. 36° F
   c. 68° F
   d. 42.4° F
2. Change 210.2° F to °C
   a. 99° C
   b. 114.8° C
   c. 320.76° C
   d. 28° C
3. Change -12° C to ° F
   a. 11.1
   b. 10.4° F
   c. 36° F
   d. 4° F

4. Change 4° F to ° C

   a. 15.55° C

   b. 20.0° C

   c. 50.4° C

   d. 28.0° C

5. Change 72° F to ° C

   a. 20° C

   b. 60.0° C

   c. 57.77° C

   d. 22.22° C

6. Calculate the calories needed to raise the temperature of 280 grams of water from 20° C to 36° C.

   a. 10080 calories

   b. 4480 calories

   c. 15680 calories

   d. 5600 calories

7. The water temperature is changed from 54° F to 160° F. If 627,200 BTU's was used, what is the weight of the water? Assume the water absorbed all the heat.

   a. 66483200 lbs.

   b. 11614.81 lbs.

   c. 3920.00 lbs.

   d. 5916.98 lbs.

8. 3200 gallons of raw sludge with a temperature of 16° C is pumped to a digester. How many BTU's are needed to raise the temperature of the sludge to 98° F (1 gallon of sludge = 8.34 lbs.).

   a. 119040.0 BTU's

   b. 1921536. BTU's

   c. 992793.6 BTU's

   d. 2188416.0 BTU's

9. How many BTU's is lost if 320 lbs. of water changed temperature from 120° F. to 90° F.

   a. 38400 BTU's

   b. 9600 BTU's

   c. 28800 BTU's

   d. 5500 BTU's

10. What is the minimum BTU/Day needed to maintain the temperature of sludge at 98° F in a digester (full) with the dimensions of 25 ft.radius, 20 ft. height. The sludge loses 2 fahrenheit degrees/hour. 1 cu. ft. of sludge weighs 64.2 lbs.

   a. 121 million BTU's

   b. 5 million BTU's

   c. 1.9 million BTU's

   d. 30.2 million BTU's

Module No:	Evaluation

Instructor Notes:	Instructor Outline:
1. Handout Answers 1. c 2. a 3. b 4. a 5. d 6. b 7. d 8. c 9. b 10. a	1. Give 10 evaluation problems.

Module No:	Module Title: Mathematics for Operators
	Submodule Title: Metric Systems
Approx. Time: 1 hour	Topic: Nomenclatures

Objectives:

The learner will demonstrate the ability to correctly identify multiples and prefixes in the metric system.

Instructional Aids:

Handout
AV (overhead transparency)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Physics for Career Education, Ewer, Nelson, Schurter, McFadden, Prentice Hall Inc. N. J.

Class Assignments:

Given 10 exercise problems to be solved.

Module No:	Topic: Nomenclature

Instructor Notes:	Instructor Outline:
1. Handout	1. Define metric systems.
	2. Discuss/demonstrate the prefixes, symbols and multiplication factors in the metric system.
	3. Give 10 exercise problems where the learner will practice to match symbols, prefixes and multiplication factors.

To be able to use metric systems one should be able to identify the prefixes. It is important to remember that metric systems are obtained by multiplying the basic unit of (one) with multiples of ten.

MULTIPLES AND PREFIXES

Multiplication Factors	Prefix	SYMBOLS
1,000,000,000,000 = 10^{12}	Tera	
1,000,000,000 = 10^{9}	Giga	
1,000,000 = 10^{6}	Mega	
1,000 = 10^{3}	KILO	k
100 = 10^{2}	Hecto	
10 = 10^{1}	Deka	
1	(Basic Unit)	
0.1 = 10^{-1}	Deci	
0.01 = 10^{-2}	CENTI	c
0.001 = 10^{-3}	MILLI	m
0.000,001 = 10^{-6}	MICRO	μ
0.000,000,001 = 10^{-9}	Nano	
0.000,000,000,001 = 10^{-12}	Pico	

Exercise

Indicate the prefix of

1. 10^{-6}
2. 10^{-3}
3. 10^{-2}
4. 10^{1}
5. 10^{-3}
6. 1000

What is the multiplication factor of

7. KILO

8. MICRO

9. MILLI

10. CENTI

11. Nano

Module No:	Module Title: Mathematics for Operators
	Submodule Title: Metric Systems
Approx. Time: 1 hour	Topic: Linear Measurements

Objectives:

The learner will demonstrate the ability to convert to the main metric unit (meter) measurement

a. Micrometer
b. Millimeter
c. Centimeter
d. Kilometer

Instructional Aids:

Handout
AV (overhead Transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Physics for Career Education, Ewer, Nelson, Schurter, McFadden, Prentice Hall Inc. N. J.

Class Assignments:

Given 10 exercise problems to be solved.

Module No:	Topic: Linear Measurement

Instructor Notes:	Instructor Outline:
1. Handout	1. Define the basic unit of the metric measurement system as the meter. 2. Discuss/demonstrate how one converts several linear metric measurement units to the base unit the meter. The units to change are: a. Micrometer b. Millimeter c. Centimeter d. Kilometer 3. Give 10 exercise problems.

The main metric unit for linear measurement (distance) is the meter.

The meter has a symbol of (m) and since it is the BASIC UNIT it has a value of one (1).

Let us review the most frequently used multiples, prefixes and symbols.

1000 = KILO = k

1 = Basic Unit = m for linear measurement

0.01 = CENTI = c

0.001 = MILLI = m

In dealing with linear measurements one should remember two items:

1. The prefix and
2. The basic unit

Example

KILO	METRE
1	2

REMEMBER that in metrics ALL VALUES of linear measurement have to end with the basic unit the meter.

The more common metric linear measurements that water and wastewater plant operators use are:

1. Micrometer (m) has a value of 1,000,000th of a meter
2. Millimeter (mm) has a value of 1000th of a meter
3. Centimeter (cm) has a value of 100th of a meter
4. Kilometer (km) has a value of 1000 meters

Example

Convert 1 meter to millimeter

Solution

Since 1 millimeter = 1/1000 of a meter

Then 1 meter = 1000 millimeters

Example

Change 16 cm to meters

Solution

1 cm = 1/100 of a meter

Therefore

16 c = 16/100 meters = 0.16 meters

Exercise

Convert

1. 0.25 mm to meters
2. 6385 meters to km
3. 428 cm to meters
4. 67 meters to mm
5. 3 cm to micrometer (μm)
6. 4 km to meters
7. 2 km to cm
8. 0.2 cm to mm
9. 0.5 cm to meters
10. A settling tank has a length of 10 meters. A baffle is placed 0.09 of a meter across the width from the end. How many cm is the baffle placed away from the end.

Module No:

Module Title:
Mathematics for Operators

Submodule Title:
Metric System

Approx. Time:
½ hour

Topic:
Volumes

Objectives:

The learner will demonstrate the ability to convert to the main metric unit measurement (liter).

a. Microliter
b. Milliliter
c. Cubic centimeter

Instructional Aids:

Handout
AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Physics for Career Education, Ewer, Nelson, Schurter, McFadden, Prentice Hall Inc. N. J.

Class Assignments:

Given 10 exercise problems to be solved.

Module No:	Topic: — Volumes

Instructor Notes:	Instructor Outline:
1. Handout	1. Define the base unit value of the metric system (liter). 2. Discuss/demonstrate how one converts 3 metric volume measurement units to the base unit (the liter). The units to change are: a. Microliter b. Milliter c. Cubic centimeter 3. Give 10 exercise problems.

The main metric unit for volume (liquid) measurement is the liter.

The liter has a symbol of (l) and since it is the BASIC UNIT it has a value of one (1).

Let us review the most frequently used multiples, prefixes and symbols.

1 = Basic Unit = l for volumes

0.001 = MILLI = m

0.000001 = MICRO = µ

Many a time one comes across linear measurement units expressing volumes.

Ex. Cubic centimeters, cubic meters indicating volume.

In metrics a volume of water of (1) milliliter occupies also a value of 1 cubic centimeter. So one can see the possibilities of different values used depending on the process and numbers.

Example

Large volumes of water are recorded in cubic meters (m^3) rather than liters.

1000 liters = 1 m^3

1 m^3 = 1,000,000 (cm^3)

Small volumes of water are measured in liters (l) or milliters (ml)

1 l = 1000 ml

And extremely small volumes of water are measured in microliters (ml)

1 ml = 1000 (ml)

or 1 ml = 1/1000 of a ml

Example

Convert 5 liters to milliters

Solution

Since 1 liter = 1000 ml

Then 5 liters = 5000 ml

Exercise

Convert

1. 10 liters to ml
2. 1000 ml to liters
3. 500 ml to liters
4. 2 ml to microliters (ml)
5. 80,000 ml to (l)
6. 50 ml to (cm^3)
7. 100 m^3 to liters
8. 70,000 liters to m^3
9. 60 ml to liters
10. A settling tank has the dimensions of 10 meters by 3 meters by 8 meters.
    a. How many (m^3) of water does it hold and
    b. How many liters does it hold.

Module No:	Module Title: Mathematics for Operators
	Submodule Title: Metric System
Approx. Time: ½ hour	Topic: Mass (weight)

Objectives:

The learner will demonstrate the ability to convert to the main metric unit measurement (gram)

a. Milligram
b. Kilogram

Instructional Aids:

Handout
AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Physics for Career Education, Ewer, Nelson, Schurter, McFadden, Prentice Hall Inc. N. J.

Class Assignments:

Given 10 exercise problems to be solved.

Module No:	Topic: Mass (weight)

Instructor Notes:	Instructor Outline:
1. Handout	1. Define MASS as the "amount of matter" in an object or a specific volume measured in grams or kilograms.
	2. Define the base unit mass (weight) of the metric system (the gram).
	3. Discuss/demonstrate how one converts metric weights to the base unit (the gram). The units to change are: a. Milligram b. Kilogram
	4. Give 10 exercise problems.

The main metric unit for mass (weight) is the gram.

The gram has a symbol of (g) and since it is the Basic Unit it has a value of one (1).

The most frequently used metric units to express weight are

a. Kilogram (kg) - has a value of 1000 grams

b. Gram (g) - the basis metric unit of weight

c. Milligram (mg) - has a value of 1/1000th of a gram

d. Microgram (μg) - has a value of 1/1,000,000 of a gram

Example

Convert 10 grams to milligrams

Solution

1 mg = 1/1000 of a gram

Therefore 1 gram = 1000 mg

10 grams - 10,000 mg

Exercise

Convert

1. 250 mg to grams
2. 68 kilograms to grams
3. 4956 grams to kilograms
4. 23.5 grams to milligrams
5. 0.2 mg to grams

In metrics there is also a correlation to volume and mass of pure water.

1 milliliter of pure water weighs 1 gram

Example

How many grams does 500 ml of water weigh?

Solution

1 ml - 1 gram

500 ml = ?

500 x 1 = 500 grams

Exercise

1. A filter paper weighs 0.002 grams. How many mg does this represent?
2. How much does 8.34 cubic centimeters of pure water weigh?
3. How many grams of chlorine is added to 20,000 liters of pure water to make a 60 mg/l concentration.
4. Convert 60 kg to mg
5. Convert 0.0005 g to mg

Module No:

Module Title: —

Mathematics for Operators

Submodule Title:

Metric Systems

Approx. Time:

1 hour

Topic:

Conversion

Objectives:

The learner will demonstrate the ability to convert

1. Metric values to English values.
2. English values to metric values.

Instructional Aids:

Handout
AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Physics for Career Education, Ewer, Nelson, Schurter, McFadden, Prentice Hall Inc. N. J.

Class Assignments:

Given 10 exercise problems to be solved.

Module No:	Topic: Conversion

Instructor Notes:	Instructor Outline:
1. Handout	Note: It is highly recommended that this type of conversion be not encouraged. 1. Discuss/demonstrate how one converts: a. Gallons to liters using the formula: Liters = Gallons x 3.75 b. Liters to gallons using the formula: $\text{Gallons} = \frac{\text{Liters}}{3.75}$ c. Lbs. to Kilograms using the formula: $\text{Kg} = \frac{\text{lbs.}}{2.204}$ d. Kilograms to lbs. using the formula: Lbs. = Kg. x 2.204
2. a. Refer to Module No. ___ Submodule Title: Weight (pounds) Topic conversion b. Refer to Module No. ___ Submodule Title: Flow Rate Topic conversion	2. Discuss/demonstrate how one converts concentration (mg/l) to kilograms if the volume of water is measured in million gallon (MG) using the formula: Kg = Mg/l x 3.78 x Q Kg = Kilogram Mg/l = Concentration in Mg/l Q = Flow rate or volume in million gallons (MG or MGD).

The conversion of English units to metrics or metric units to English can be attained by using conversion factors. The simplest to use are:

1 inch = 2.54 cm
1 gallon = 3.75 liters
2.204 pounds = 1 kg.

Example

Convert 15 lbs. to kg.

Solution

2.204 lb. = 1 kg.

15 lbs. = X kg

$$\frac{15 \text{ lbs.} \times 1 \text{ kg}}{2.204 \text{ lbs.}} = 6.81 \text{ kg}$$

A special interest to water and wastewater plant operators is the conversion of lbs/day to kg/day.

Example

Calculate the kg/day of solids if the flow of water is 135,000 gallons and the solid concentration is 30 mg/l.

Solution

lbs./day = mg/l x 8.34 x Q

= 30 x 8.34 x .135

= 33.777 lbs./day

Since 2.204 lbs. = 1 kg

Then

$$\frac{33.777}{2.204} = 15.33 \text{ kg/day}$$

Another method of converting concentration (mg/l) to kg/day using Q in gallons/day is to use the formula

kg/day = mg/l x 3.78 x Q

If the flow is recorded in cubic meters/day (m^3/day). The formula to use in converting concentration to kg/day is

kg/day = conc. (mg/l) x Q m^3/day) x 0.001

Example

The flow to a treatment plant is 60,000 m^3/day and the concentration of BOD is 188 mg/l. What is the kg/day of BOD?

Solution

kg/day = Conc. x Q x .001

= 188 x 60,000 x .001

= 11280 kg/day

Exercise

1. Convert 165,000 gallons to liters.
2. Convert 165,000 gallons to cubic meters
3. Convert 4 feet to meters
4. Convert 385 lbs. to kilograms
5. Convert 56,000 mg to lbs.
6. How many cubic meters of water does a 14 inch water main 20 feet long hold?
7. The BOD concentration of a wastewater flow is 22 mg/l. The flow is 188,000 gallons/day. Calculate the kg/day of BOD in the wastewater.
8. How many kg is a 150 lb. cylinder of chlorine.
9. You need to feed sodium flouride (Na F) into your water at a rate of 0.005 grams per second for 24 hours. How many lbs. of Na F is needed for a day.
10. How many kg/day of chlorine is used if the flow is 0.2 MGD and the dose concentration is 8.2 mg/l.

Module No: —	Module Title: Mathematics for Operators
Approx. Time: 1 hour	Submodule Title: Metric Systems
	EVALUATION

Objectives:

The learner will demonstrate the ability to determine correctly the answers to 8 out of 10 problems related to metric systems.

1. Measurements
2. Volumes
3. Mass
4. Conversion

1. Convert 6000 meters to kilometers

   a. .6

   b. 6

   c. 600

   d. 60

2. Convert 5 liters to milliters

   a. 50

   b. .5

   c. 5000

   d. 500

3. Convert 26 grams to mg

   a. 26000

   b. .26

   c. .026

   d. .0026

4. Convert 0.0156 grams per liter to mg/l

   a. 156 mg/l

   b. 1.56 mg/l

   c. 15.6 mg/l

   d. .00156 mg/l

5. A flow to a treatment plant of 160,000 m^3/day contains 40 mg/l of calcium. How many kg/day of calcium does the flow contain?

   a. 6.4

   b. 6400

   c. 53.4

   d. 640

6. The volume of wastewater measured is 289,000 gallons/day. The chlorine applied to the flow is at a dose of 12.2 mg/l. How many kg of Cl_2 is used?

   a. 13222 kg

   b. 29.4 kg

   c. 13.3 kg

   d. 2.94 kg

7. The dimensions of a tank is 20 meters by 12 meters x 3 meters. What is the volume of water it contains?

   a. 7.2 m^3

   b. 4320 m^3

   c. 72000 m^3

   d. 720 m^3

8. Your laboratory requires a minimum of 6 liters of sample. How many gallons does this represent?

   a. 6000

   b. 1.6

   c. .16

   d. 16

9. Convert 2.2 MGD to m^3/day

   a. 825 m^3/day

   b. 8250 m^3/day

   c. 82500 m^3/day

   d. 2220 m^3/day

10. Convert the cost of a 150 lbs chlorine purchased for $70.00 to dollars per kg.

    a. 0.47 $/kg

    b. 1.03 $/kg

    c. .103 $/kg

    d. 8.6 $/kg

Module No:	Evaluation
Instructor Notes:	Instructor Outline:
1. Handout Answers 1. b 2. c 3. a 4. c 5. b 6. c 7. d 8. b 9. b 10. b	1. Give 10 evaluation problems.

Module No:	**Module Title:** Mathematics for Operators
	Submodule Title: Hydraulic Loading
Approx. Time: 3 hours	**Topic:** Hydraulic Loading

Objectives:

The learner will demonstrate the ability to calculate correctly the hydraulic loading of a plant or unit process.

1. Hydraulic loading/surface settling rate
2. Weir overflow rate

Instructional Aids:

Handout
AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept. of Env. Conservation.

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association.

Class Assignments:

1. Read handout
2. Given 10 exercise problems to be solved.

Module No:	Topic: Hydraulic Loading

Instructor Notes:	Instructor Outline:
1. Give handout	1. Discuss and demonstrate how one calculates the hydraulic loading using the formula:
Units	$HL = \frac{Q}{SA}$
HL = Gallons per day per unit surface area	HL = Hydraulic loading
Q = Gallons per day	Q = Flow rate
Surface area depends on the unit process	SA = Surface area
Depending on the unit process HL has a value of:	
1. Filters a. GPD/ft^2 b. GPD/acre c. GPM/ft^2	
2. Clarifiers a. GPD/ft^2 b. GPD/acre	
3. Trickling filters a. GPD/ft^2 b. GPD/acre c. MGAD	
4. Secondary clarifiers a. GPD/ft^2 b. GPD/acre	

Module No:	Topic: Hydraulic Loading

Instructor Notes:	Instructor Outline:

5. Rotating biological filters
    a. GPD/ft^2
6. Waste stabilization ponds
    a. GPD/acre
    b. MGAD

The unit values are:

WOR = GPD/ft.

Q = GPD

WL = ft.

2. Discuss and demonstrate how one calculates the weir overflow rate using the formula:

WOR = Weir overflow rate

Q = Flow rate

WL = Weir length

Module No:	Topic: Hydraulic Loading

Instructor Notes:	Instructor Outline:
Indicate the different types and shapes of weirs	3. Give exercise problems.

The hydraulic loading of a treatment unit is defined as the amount of water applied to a specific surface area.

IT IS ALSO KNOWN AS THE SURFACE SETTLING RATE.

That is if one adds 5 gallons of water on a 1 square foot, then the hydraulic loading is 5 gal./ft^2

The formula to use is

$$HL = \frac{Q}{SA}$$

HL = Hydraulic loading

Q = Flow rate

SA = Surface area

Example

What is the hydraulic loading of a clarifier if the flow is 600,000 gallons per day and the surface area is 600 sq. ft.

Solution

$$HL = \frac{Q}{SA}$$

$$= \frac{600,000}{600}$$

$$= 6000 \text{ GPD/ft}^2$$

This means that 6000 gallons of water per day is applied to one square ft.

Hydraulic loading is used in many different operational units by operators. It is mainly a design factor that one attempts to maintain so as to get good operation.

The units that HL is used in are

a. Filters such as sand filters, pressure filters, carbon filters, and filters using the upflow design. Hydraulic loading in filters has a value of

    1. GPM/ft^2
    2. GPD/ft^2
    3. GPD/Acre

b. Clarifiers/Settling Basis/Sedimentation units. Hydraulic loading values are reported in

   1. GPD/ft^2

   2. GPD/acre

c. Trickling filters/Rotating biological filters/ Waste Stabilization Ponds/ Polishing lagoons. Hydraulic loading values are reported in

   1. GPD/ft^2

   2. GPD/acre

   3. MGAD

THE VALUES OF Q (FLOW RATE) AND SA (SURFACE AREA) DEPEND ON THE VALUE OF HYDRAULIC LOADING.

Example

The value of HL is GPD/ft^2, then Q = GPD and SA = ft^2

Example

The value of HL is GPM/ft^2, then Q = GPM and SA = ft^2

Exercise

1. A settling basin has a surface area of 385 sq. ft. The flow to the basin is 24 MGD. What is the hydraulic loading in GPD/ft^2

2. Calculate the hydraulic loading of a lagoon with an area of 9 acres and a flow of 0.6 MGD. Ans. in MGAD.

3. Calculate the hydraulic loading of a primary clarifier 50 x 20 if the flow is 1.3 MGD. Ans. in GPD/ft^2

4. Calculate the surface settling rate of a clarifier 25 ft. in radius and a flow of 2 cubic feet/sec. GPD ft^2

5. Calculate the upflow rate on a water treatment filter with a radius of 12 ft. in diameter and flow rate of 340 GPM. Ans. in GPM/ft^2

6. A sand filter 15 ft. x 6 ft. receives a flow of 450 GPM. Calculate the hydraulic loading. Ans. in GPM/ft^2

7. A trickling filter 30 ft. radius and 6 ft. deep receives a flow of 155,000 GPD. Calculate hydraulic loading in GPD/ft^2

Weir Overflow Rate

Weir overflow rate (WOR) is calculated by dividing the flow rate of water by the length of the weir.

Weir overflow rate is also known as weir loading

IT IS IMPORTANT TO REMEMBER THAT WEIR LENGTH IS THE TOTAL LENGTH OF WEIR FROM WHERE WATER IS REMOVED FROM A UNIT.

The formula to use is

$$WOR = \frac{Q}{WL}$$

WOR = Weir overflow rate

Q = Flow rate

WL = Weir length

The usual unit values of WOR is in GPD/ft.

Example

The weir length of a circular clarifier is 157 ft. The flow rate to the clarifier is 117,750 GPD. Calculate the weir overflow rate.

Solution

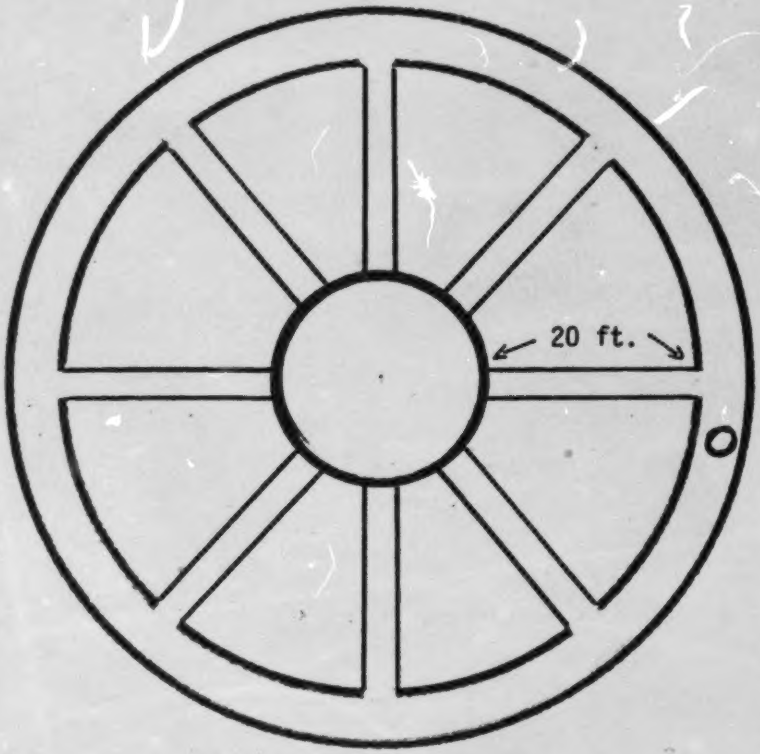
$$WOR = \frac{Q}{WL}$$

$$= \frac{117,750}{157}$$

$$= 750 \text{ GPD/ft.}$$

Exercise

1. A rectangular clarifier 40 ft. length, 20 ft. wide and depth of 8 ft. The flow rate is 11 GPM. The direction of the flow through the clarifier is through the length. Calculate the weir overflow rate. (Ans. in GPD/ft.
2. A circular settling basin with a weir radius of 30 ft. and a flow rate of .123 MGD. Calculate the weir overflow rate.
3. A flocculator clarifier (See sketch for details) receives a flow of 3 million gallons/day. Calculate the weir overflow rate.


20 ft.
O

Module No:	Module Title: Mathematics for Operators
	Submodule Title: Hydraulic Loading
Approx. Time: 1 hour	EVALUATION

Objectives:

The learner will demonstrate the ability to determine correctly the answers to 8 out of 10 problems related to hydraulic loading of a unit process related to water and wastewater technology.

1. A square settling tank 35' x 35' x 7.5 (H) receives a flow of 475 GPM. The weir length is 140 in.length. What is the hydraulic loading?

   a. 4885.7 GPD/ft^2

   b. 7.5 GPD/ft^2

   c. 558.36 GPD/ft^2

   d. 13.57 GPD/ft^2

2. In Problem 1 what is the weir overflow rate?

   a. 4885.7 GPD/ft.

   b. 7.5 GPD/ft.

   c. 558.36 GPD/ft.

   d. 13.57 GPD/ft.

3. The weir diameter of a circular clarifier is 55 feet. The clarifier receives a flow of 6.25 GPS. Calculate the weir overflow rate.

   a. 3126.8 GPD/ft.

   b. 113.7 GPD/ft.

   c. 227.4 GPD/ft.

   d. 52.2 GPD/ft.

4. In Problem 3 what is the surface settling rate?

    a. 3126.8 GPD/ft^2

    b. 113.7 GPD/ft^2

    c. 227.4 GPD/ft^2

    d. 52.2 GPD/ft^2

5. A pressure filter 10 ft. in diameter receives a flow of 300 GPM. Calculate the hydraulic loading.

    a. 3.8 GPM/ft^2

    b. 1 GPM/ft^2

    c. 15 GPM/ft^2

    d. 5503 GPM/ft^2

6. A lagoon 350' wide and 475' long and 4'deep. What is the hydraulic loading if the flow is.5 MGD.

    a. 263 GPD/ft^2

    b. 357 GPD/ft^2

    c. 0.75 GPD/ft^2

    d. 3 GPD/ft^2

7. A sand filter 15 ft. x 5 ft. receives a flow of 350,000 gallons/day. What is the hydraulic loading?

    a. 4666.6 GPM/ft^2

    b. 3.24 GPM/ft^2

    c. 15 GPM/ft^2

    d. 5 GPM/ft^2

8. A standard trickling filter with a radius of 38 ft. receives a flow of 200,000 GPD. Calculate the hydraulic loading.

    a. 838 GPD/ft.

    b. 44 GPD/ft^2

    c. 419 GPD/ft^2

    d. 265 GPD/ft^2

9. A circular clarifier has a diameter of 75 ft. The weir diameter is 72 ft. The flow for the day is 2,500,000 gallons. What is the weir loading?

   a. 11058 GPD/ft.

   b. 10615 GPD/ft.

   c. 154 GPD/ft.

   d. 3472 GPD/ft.

10. A clarifier 42 ft. long, 30 ft. wide and 8 ft. deep receives a flow of 1250 GPM. What is the weir overflow rate if the weir length is 30 ft.

    a. 42 GPM/ft.

    b. 1429 GPM/ft.

    c. 179 GPM/ft.

    d. 30 GPM/ft.

Module No:	Topic: Hydraulic Loading

Instructor Notes:	Instructor Outline:
1. Handout	1. Give 10 evaluation problems.
Answers 1. c 2. a 3. a 4. c 5. a 6. d 7. b 8. b 9. a 10. a	

Module No:	**Module Title:** Mathematics for Operators
	Submodule Title: Organic Loading
Approx. Time: 3 hours	**Topic:** Solid Loading

Objectives:

1. The learner will demonstrate the ability to calculate the solid loading of a unit process.
2. The learner will demonstrate the ability to calculate the pounds of BOD loading to a unit process.

Instructional Aids:

Handout
AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept. of Env. Conservation.

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association.

Class Assignments:

1. Read handout
2. Given 10 exercise problems to be solved.

Module No:	Topic: Solid Loading

Instructor Notes:	Instructor Outline:
1. Give handout	1. Solids
a. Indicate the type of solids 1. Total solids 2. Total suspended solids Solid loading has a unit value of lbs/ft.^{3} lbs. of solids obtained from mg/l of solids x 8.34 x Q V has a unit value of cubic feet	a. Discuss and demonstrate how one calculates the solids loading using the formula: Solid Loading = amount of solids applied to a unit volume Mg/l of solids = concentration of solids Q = flow rate V = volume of tank
b. 1. Solids has a unit value of gallons/ft.^{3} Volume of tank has a unit value of cubic feet % solids can either be total solids or total volatile solids. 2. Indicate that this formula is usually used in digester loading.	b. Discuss and demonstrate how one calculate the volume of solids applied to a unit process using the formula: Solids = volume of sludge pumped x decimal % of solids Divided by volume of tank
Organic loading has a unit value of: Lbs. of BOD per unit volume Ex. lbs/1000 ft.^{3} lbs/acre-ft. lbs/ft.^{3} lbs. of BOD is obtained from: mg/l x 8.34 x Q V has a unit value of cubic feet	2. Discuss and demonstrate how one calculates the BOD loading to a unit value using the formula: $OL = \frac{\text{lbs. of BOD}}{V}$ OL = Organic loading - the amount of BOD added to a volume lbs. of BOD = pounds of BOD V = volume of tank

Module No:	Topic: Solids Loading
Instructor Notes:	**Instructor Outline:**
Indicate that this formula is used in: 1. Trickling filters 2. Activated sludge 3. Lagoons 4. Rotating biological filters 5. Digesters	3. Give exercise problems 4. Review the exercise problems.

Solids Loading

Solids loading is defined as the amount of organic matter that is applied to specific volume.

The organic matter can be in the form of:

a. BOD

b. COD

c. Total Solids

d. Total Suspended Solids

e. Total Volatile Solids

SOLIDS LOADING IS ALSO KNOWN AS ORGANIC LOADING

The formula to use is

$$OL = \frac{lbs.}{V}$$

OL = Organic Loading

lb. = lbs. of organic matter

V = Volume of tank

The processes where solids loading is a design factor are:

a. Trickling Filters

b. Activated Sludge

c. Waste Stabilization Lagoons

d. Rotating Biological Filters

e. Digesters

The unit values of solids loading are:

a. lbs/ft^3 or

b. lbs/100 ft. or

c. lbs/acre ft.

Example

Calculate the solid loading of 13,300 lbs of BOD onto a trickling filter with a volume of 332500 cu. ft.

Solution

$$OL = \frac{lbs.}{V}$$

$$= \frac{13300}{332500}$$

$$= 0.04 \text{ lbs/cu. ft.}$$

Example

Calculate the solids loading of 26600 lbs. of BOD into a trickling filter with a volume of 332500 cu. ft. Ans. in 1000 cu. ft.

Solution

$$OL = \frac{lbs.}{V}$$

Since the answer has to be in 1000 cu. ft. then V has to be in 1000 cu. ft. So 332500 = 332.5/1000 cu. ft.

$$OL = \frac{26600}{332.5}$$

$$= 80 \text{ lbs./1000 cu. ft.}$$

Exercise

1. A standard rate trickling filter with a diameter of 55 ft. and a media depth of 6 ft. receives a flow of .95 MGD and a BOD concentration of 125 mg/l. Calculate the solids loading per 1000 cu. ft.

2. A digester 30 ft. in diameter 15 ft. deep receives a volume of 5000 lbs. of sludge a day. Calculate the solids loading.

3. A high rate trickling filter 80 ft. diameter, 4 ft. media depth receives a flow of 1.5 MGD and a BOD concentration of 180 mg/l. Calculate the solids loading per 1000 cu. ft.

4. Two trickling filters each 100 ft. in diameter and a depth of 7 ft. The flow applied to both is .5 MGD and the BOD concentration is 150 mg/l. Calculate the organic loading to the filters. Ans. in lbs/acre - ft/day.

5. Two trickling filters each 50 ft. radius has a depth of 6 ft. Each filter receives a flow of .5 MGD and a BOD concentration of 175 mg/l. Calculate the organic loading in lbs/1000 cu. ft.

6. A digester with a diameter of 45 ft. in diameter and depth of 11 ft. receives a flow of 6000 gallons of sludge. The sludge has a concentration of 6% solids and the solids is 62% volatile solids. Calculate the volatile solids loading. Assume 1 gallon of sludge = 8.7 lbs.

7. A two stage trickling filter process trickling filter #1 80 ft. in diameter and 6 ft. depth. Filter #2 75 ft. in diameter and 6 ft. depth. The flow to the plant is 1.4 MGD. The applied BOD to filter #1 is 260 mg/l. The applied BOD to filter #2 95 mg/l. Calculate the organic loading on each filter.

8. A standard trickling filter 45 ft. x 35 ft. x 5 ft. receives a flow of 124000 gallons with a BOD concentration of 152 mg/l. Calculate the organic loading in lbs/1000 cu. ft.

9. In an activated sludge process the aeration basin has the dimensions of 12 ft. x 65 ft. x 10 ft. The flow is 300,000 gallons per day with a BOD concentration of 120 mg/l. Calculate the organic loading /1000 cu. ft.

10. In a conventional activated sludge process the BOD influent is 400 mg/l. The primary system removes 18% of the BOD. The aeration basin has the dimensions of 35 ft. x 18 ft. x 12 ft. The flow into the plant is at a rate of 58 GPM. Calculate the organic loading of the aeration basin in lab/1000 cu. ft.

Module No:	Module Title: Mathematics for Operators
Approx. Time: 1 hour	Submodule Title: Organic Loading
	EVALUATION

Objectives:

The learner will demonstrate the ability to determine correctly the answers to 8 out of 10 problems related to solid loading of a unit process related to water and wastewater technology.

1. If 280 lbs. of BOD is applied to a trickling filter with a radius of 20 ft. and a rock depth of 6 ft. What is the organic loading?

   a. 3.7 lbs/1000 ft.^{3}

   b. 26.9 lbs/1000 ft.^{3}

   c. 148.6 lbs/1000 ft.^{3}

   d. 37.2 lbs/100 ft.^{3}

2. To a digester 25 ft. diameter and 15 ft. deep, volume of 400 gallons/days of sludge, 3% total solids with a volatile solid content of 72%. Calculate the gallons of volatile solids applied to the digester.

   a. 39 lbs/1000 ft.^{3}

   b. 0.3 lbs/1000 ft.^{3}

   c. 1.2 lbs/1000 ft.^{3}

   d. 4.8 lbs/1000 ft.^{3}

3. Two trickling filters each 110 ft. diameter with a media depth of 7 ft. A flow of 750,000 GPD is split and applied to the filters. If the flow contains 110 mg/l of BOD what is the organic loading applied to each filter.

   a. 386.6 lbs/1000 ft.^{3}

   b. .100 lbs/1000 ft.^{3}

   c. .0026 lbs/100 ft.^{3}

   d. 10.35 lbs/1000 ft.^{3}

4. An aeration basin with the dimensions of 35 ft. length, 18 ft. width and 8 ft. deep receives a flow of 195,000 gallons and a BOD concentration of 285 mg/l. Calculate the organic loading.

   a. 82.7 lbs/1000 ft.^{3}

   b. 92.0 lbs/1000 ft.^{3}

   c. 0.01 lbs/1000 ft.^{3}

   d. 10.9 lbs/1000 ft.^{3}

5. If 8500 gallons of 4% sludge is pumped per day to a digester with a diameter of 40 ft. and a depth of 12 ft. Calculate the total solids loading per day.

   a. 0.18 gallons/1000 ft.^{3}

   b. 5.6 gallons/1000 ft.^{3}

   c. 22.6 gallons/1000 ft.^{3}

   d. 0.04 gallons/1000 ft.^{3}

6. In a two stage trickling filter process, trickling filter #1, 110 ft. in diameter and a depth of 4 ft. and trickling filter #2, 85 ft. in diameter and 5 ft. depth receives a flow of 1700 GPM. The raw BOD is 610 mg/l. If the primary clarifier reduces the BOD by a 15% and trickling filter further reduces the BOD from the primary effluent by 35%, what is the organic loading of trickling filter #2.

   a. 5.24 lbs/acre-ft/day

   b. 8.76 lbs/acre-ft/day

   c. 242.6 lbs/acre-ft/day

   d. 10568 lbs/acre-ft/day

7. A standard rate trickling filter dimensions of 45 ft. diameter and a media depth of 7 ft. receives a flow of 635,000 gallons per day if the BOD concentration is 121 mg/l. Calculate the organic loading.

   a. 14.4 lbs/1000 ft.^{3}

   b. 57.6 lbs/1000 ft.^{3}

   c. 0.016 lbs/1000 ft.^{3}

   d. 1.44 lbs/1000 ft.^{3}

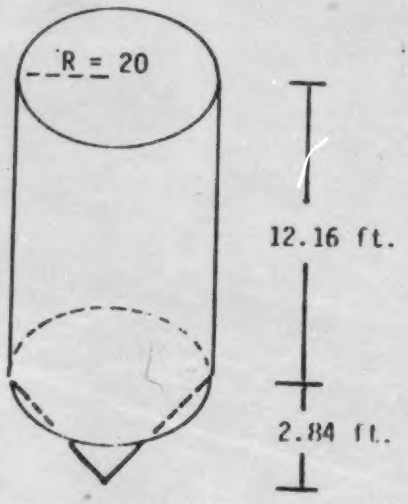
8. A digester (see sketch for details) receives a volume of sludge of 2300 gallons of sludge with a 4.8% total solids and 69% volatile solids content. Calculate the volatile solids loading in gallons/1000 ft.^{3}

   a. 4.04 gallons/1000 ft.^{3}

   b. 0.22 gallons/1000 ft.^{3}

   c. 4.63 gallons/1000 ft.^{3}

   d. 18.5 gallons/1000 ft.^{3}



9. To a digester 30 ft. in diameter and 18 ft. deep a volume of 1200 gallons/day of sludge. The total solid content is 4% and volatile solids content of 65%. Calculate the total solids loading applied to the digester. (1 gallon of sludge = 8.7 lbs.)

   a. 32.8 lbs/1000 ft.^{3}

   b. 0.031 lbs/1000 ft.^{3}

   c. 121.8 lbs/1000 ft.^{3}

   d. 0.122 lbs/1000 ft.^{3}

10. A waste treatment plant with 5 trickling filters each 95 ft. in diameter and a depth of 5.5 ft. The flow rate to the plant is 1.45 MGD and has a BOD content 185 mg/l. Calculate the organic loading to the filters.

    a. 500 lbs/acre-ft/day

    b. 50 lbs/acre-ft/day

    c. 2.8 lbs/acre-ft/day

    d. 0.05 lbs/acre-ft/day

Module No:	Topic: Solid Loading

Instructor Notes:	Instructor Outline:
1. Handout	1. Give 10 evaluation problems
Answers	
1. d	
2. c	
3. d	
4. b	
5. c	
6. d	
7. b	
8. c	
9. a	
10. a	

Module No:

Module Title:
Mathematics for Operators

Submodule Title:
Digester

Approx. Time:
1 hour

Topic:
Digester Loading

Objectives:

The learner will demonstrate the ability to determine the loading of a digester based upon:

1. The total solid content of the sludge
2. The volatile solid content of the sludge

Instructional Aids:

Handout

AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept. of Env. Conservation

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association

Class Assignments:

Given 10 exercise problems to be solved.

Module No:	Topic: Digester Loading
Instructor Notes:	Instructor Outline:
1. Handout	1. Discuss/demonstrate how one calculates the volume of sludge pumped to a digester using a. Piston Pump Volume of sludge = Volume of Piston x No. of strokes b. Centrifugal Pump Volume of sludge = Pump capacity (GPM) x 60 x Total hours pump is in operation
	2. Give 4 exercise problems
3. The % Total Solids concentration is obtained from laboratory tests.	3. Discuss/demonstrate how one calculates the volume of solids pumped to a digester using the % total solid concentration of solids in sludge. The formula to use is: Volume of solids = Volume of sludge x decimal % of total solids.
	4. Give 4 exercise problems
5. The % Volatile Solids concentration is obtained from laboratory tests.	5. Discuss/demonstrate how one calculates the volume of volatile solids pumped to a digester using the % Volatile Solid concentration in solids being pumped. The formula to use is: Volume of Volatile Solids = Volume of Solids Decimal % of Volatile Solids
	6. Give 4 exercise problems.

Basic digester operation depends on knowing

1. The volume of digester
    a. Cubic feet ($ft.^3$)
    b. Gallons
2. The % total solids pumped to the digester
3. The % volatile solids pumped to the digester
4. The total gallons of sludge pumped to the digester

1. The volume of a digester

    Usually the digester is made up of two shapes

    1. A cylinder $V = \pi R^2 \times H$
    2. A cone $V = 1/3 \pi R^2 \times h$

2. The % total solids and the % total volatile solids are obtained from laboratory analysis.

3. The total gallons of sludge pumped to the digester is obtained from daily records. If such records do not exist, several ways can be taken to determine the volume of sludge depending on the type of pump.

    a. If a piston pump is used than calculate the volume of the piston. Volume of sludge = Volume of piston x No. of strokes.

    b. If a centrifugal pump is used than calculate the volume of the sludge. Volume of sludge = Pump capacity (GPM) x total hours pump operated x 60.

    c. If a progressive cavity such as a Moyno Pump is used the same principle used in calculating the volume of sludge pumped by centrifugal pump.

Example 1

A cylinder of a piston pump has a volume of ½ $ft.^3$ The total number of strokes registered is 3000. What is the volume of sludge pumped.

Solution

Vol. of sludge = Vol. of piston x No. of strokes

$= .5\ \text{ft.}^3 \times 3000$

$= 1500\ \text{ft.}^3$

Example 2

A centrifugal pump has a capacity of 50 GPM. The total hours the pump operated is two (2). Calculate the volume of sludge.

Solution

Vol. of sludge = Pump capacity (GPM) x Hrs. x 60

= 50 GPM x 2 x 60

= 6000 gallons

Exercise

1. Calculate the volume of sludge pumped to a digester if the pump has a cylinder capacity of 0.4 ft.^{3} and the number of strokes is 2500.
2. Calculate the volume of sludge pumped to a digester if the pump has a cylinder capacity of 3 gallons and the number of strokes is 4181.
3. Calculate the volume of sludge pumped if the pump has a capacity of 130 GPM and the No. of operating hours of 3.
4. Calculate the volume of sludge pumped using a pump with a capacity of 60 GPM and total operating time is 3.2 hours.

Digester Loading

To be able to determine the amount of total solids added to a digester, use the:

Formula

(Amount of solids = Volume of sludge x Decimal % of solid concentration)

Example 1

Calculate the amount of solids pumped to a digester if the % concentration of total solids is 4% and the volume of sludge pumped is 11520 gallons.

Solution

Amount of solids = Vol. of sludge x Decimal % of T.S.

= 11520 x 0.04%

= 461 gallons

Example 2

Calculate the amount of solids pumped to a digester if the total solids concentration is 6% and the volume of sludge pumped is 1200 $ft.^3$

Solution

Amount of solids = Volume of sludge x Decimal % of T.S.

= 1200 $ft.^3$ x 0.06%

= 72 $ft.^3$

Exercise

1. Calculate the amount of total solids pumped to a digester if the concentration of total solids is 5% and the volume of sludge pumped is 2000 gallons.
2. The volume of sludge pumped to a digester is 7000 gallons. The lab reports the solids concentration is 7% total solids. What is the amount of solids pumped to the digester?
3. Calculate the amount of total solids added to a digester if the concentration is 4.5% total solids and the volume of the sludge added 5500 gallons.
4. The volume of sludge pumped to a digester is 9000 cu. ft. and the per cent total solids is 3%. Calculate the amount of solids added to the digester.

Digester Loading

Since volatile solids are very important in digester operation, one should be able to determine the amount of volatile solids (V.S.) added to the digester. This is accomplished by knowing:

1. The amount of total solids added

2. The % concentration of volatile solids

Formula

Amount of volatile solids = Amount of total solids x Decimal % concentration of volatile solids

Example

Calculate the amount of volatile solids added to a digester if the % concentration of volatile solids is 60% and the amount of total solids pumped is 100 gallons.

Solution

VS = T.S. x Decimal % of V.S.

= 100 gal. x .6%

= 60 gallons

Exercise

1. The % concentration of 490 gallons of total solids pumped to a digester is 70%. Calculate the amount of volatile solids pumped to the digester.

2. The amount of total solids pumped to a digester is 247.5 gallons. The concentration of volatile solids is 65%. Calculate the amount of volatile solids added to the digester.

3. 270 cu. ft. of solids with a concentration of 62% volatile solids is pumped to a digester. What is the amount of volatile solids added to the digester.

4. Calculate the amount of volatile solids added to a digester if the amount of solids added is 1500 gallons and the % concentration of volatile solids is 73%.

Module No:

Module Title:
Mathematics for Operators

Submodule Title:
Digester

Approx. Time:
1 hour

Topic:
% Volatile Solid Reduction

Objectives:

The learner will demonstrate the ability to determine the % of Volatile Solids reduction in a digestion process.

Instructional Aids:

Handout

AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept. of Env. Conservation

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association

Class Assignments:

Given 4 exercise problems to be solved.

Module No:	Topic: % Volatile Solids Reduction

Instructor Notes:	Instructor Outline:
1. Handout	1. Discuss/demonstrate how one is able to determine the % volatile solids reduction in a digestion process using the formula: $P = \frac{in - out}{in - in \times out} \times 100$ P = % Volatile Solid reduction in = Decimal % of volatile solids added to the digester out = Decimal % of volatile solids remaining in digested sludge
	2. Give 4 exercise problems

Volatile Solids Reduction

Volatile solids reduction is a method of determining the amount of volatile solids that have been converted to gas, since the only material is a digester that has any food value to the microorganism is the volatile solids, then by monitoring the input and output of the volatile solids into a digester one can determine the reduction.

Formula

The formula to use is very similar to the regular efficiency formula used quite extensively throughout wastewater treatment.

$$P = \frac{\text{In-out}}{\text{In-(In x out)}} \times 100$$

P = % Volatile solid reduction

In = Decimal % of volatile solids added to a digester

Out = Decimal % of volatile solids remaining in digested sludge

Example

The volatile solids test shows a content of 68% volatile solids of the sludge added to a digester. The test also shows that the volatile solids content of sludge added to a drying bed is 48%. What is the reduction of the solids.

Solution

$$P = \frac{\text{In - out}}{\text{In - (In x out)}} \times 100$$

$$= \frac{.68 - .48}{.68 - (.68 \times .48)} \times 100$$

$$= \frac{.2}{.68 - .33} \times 100$$

$$= \frac{.2}{.35} \times 100$$

$$= 57\%$$

Exercise

1. The lab results indicate that raw sludge pumped to a digester has a volatile content of sludge applied to the drying bed is 62%. What is the volatile solid reduction.

2. Raw sludge pumped to a digester has volatile content of 69% and after digestion the volatile content of the sludge is 48%. What percent of the sludge was transformed to gas?

3. Lab results indicate that sludge before digestion is 78% volatile and after digestion is 54% volatile. What is the percent of volatile matter destroyed.

4. A cylinder of a piston pump has a volume of ½ $ft.^3$ The total number of strokes registered is 3000. The lab tests indicate the % solids of pumped sludge to be 4% and the volatile solids to be 60%. After digestion the sludge had a volatile solid content of 48%. What is the volume in cu. ft. of the sludge digested.

Module No:	Module Title: Mathematics for Operators
Approx. Time: 1 hour	Submodule Title: Digester EVALUATION

Objectives:

The learner will demonstrate the ability to determine correctly the answers to 8 out of 10 problems related to:

1. Digester loading
2. % reduction in volatile solids

1. A sludge pump has a capacity of 15 GPM. The sludge contains 2% solids and a volatile solid concentration of 65%. The sludge is fed continuously to a digester. How many gallons of solids is pumped to a digester every day?

   A. 180 gallons
   B. 432 gallons
   C. 43200 gallons
   D. 21600 gallons

2. In Problem No. 1 how many lbs. of volatile solids was pumped to the digester per day. Assume that 1 gallon of sludge weighs 8.34 lbs.

   A. 1170.94 lbs.
   B. 2341.87 lbs.
   C. 28080 lbs.
   D. 280.8 lbs.

3. Lab tests indicate that raw sludge has a volatile content of 72% and digested sludge of 42%. What is the volatile solid reduction?

   A. 42%
   B. 72%
   C. 58%
   D. 21.6%

4. A digester receives 2000 gallons of sludge with a total solid content of 6% and volatile solids of 70%. Calculate the amount (gallons) of volatile solids pumped to the digester.

   A. 461 gallons
   B. 29 gallons
   C. 840 gallons
   D. 1400 gallons

5. A sludge pump rated at 2 GPS operates for 10 hours/day and the sludge analysis provides the results of 6.9% total solids and 72% volatile solids. Calculate the gallons of total solids pumped/day.

   A. 11923
   B. 4968
   C. 3577
   D. 83

6. A cylinder of a sluge pump has a diameter of 8 inches and a stroke of 6 inches. The pump is operated for 1850 strokes a day. The solid concentration is 4.8% and the volatile solid concentration is 73%. After digestion the volatile solid concentration is 56%. Calculate the volume (gallons the sludge pumped). Assume 1 cu. ft. = 7.48 gallons.

   A. 2414 gallons
   B. 158 gallons
   C. 77247 gallons
   D. 9956 gallons

7. In Problem 3 what is the total volume of solids pumped to the digester?

   A. 3708 gallons
   B. 116 gallons
   C. 464 gallons
   D. 48 gallons

8. In Problem 3 what is the volume of volatile solids in cu. ft.

   A. 362 cu. ft.
   B. 45 cu. ft.
   C. 11 cu. ft.
   D. 15 cu. ft.

9. In Problem 3 what is the weight of the sludge that is digested. 1 gallon = 8.34 lbs.

   A. 66 lbs.
   B. 1197 lbs.
   C. 374 lbs.
   D. 180 lbs.

10. Raw sludge pumped to a digester has a volatile content of 68% and after digestion the volatile content of the sludge is 41%. What percent of the sludge was destroyed.

   A. 86%
   B. 67%
   C. 38%
   D. 60%

Module No:	— Evaluation
Instructor Notes:	Instructor Outline:
1. Handout Answers 1. b 2. d 3. b 4. c 5. b 6. a 7. b 8. c 9. c 10.b	1. Give 10 evaluation problems.

Module No:

Module Title:
Mathematics for Operators

Submodule Title:
Chemical Addition

Approx. Time:
3 hours

Topic:
Chemical Addition

Objectives:

The learner will demonstrate the ability to calculate:

1. The amount (weight) of chemicals added (dose), needed (demand) and residual material in a specific process as applied to water and wastewater technology.
2. The amount of chemicals needed to perform a specific process by interpreting laboratory results.
3. The feed rate of chemicals to a process stream to maintain a specific concentration .

Instructional Aids:

Handout
AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept. of Env. Conservation.

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association.

Class Assignments:

1. Read handout
2. Given 10 exercise problems to be solved.

Module No:	Topic:
	Chemical Addition

Instructor Notes:	Instructor Outline:
	1. a. Discuss and demonstrate how one calculates for the amount of chemical added to a system using the formula:
	lbs. = conc. x 8.34 x Q
	lbs. = lbs. of chemical
conc. is in mg/l	conc. = concentration of chemical
Q is in MG or MGD	Q = flow rate or volume of tank
	b. Discuss and demonstrate how one calculates the amount of chemicals needed if the strength of the solute can only attain specific percentage using the formula:
	$\text{lbs} = \dfrac{\text{conc. x 8.34 x Q}}{\text{decimal \% strength}}$
	lbs. = lbs. of chemical usually dry
	conc. = concentration of chemical
	Q = Flow rate or volume of tank
	Decimal % strength = The % concentration of useful and available chemical.
	2. a. Discuss and demonstrate how one calculates the concentration or amount of chemicals needed (demand) using the formula:
	Demand = Dose - Residual (need)
	b. Discuss and demonstrate how one calculates the amount of chemicals needed by interpreting laboratory results using the proportional formula:

Module No:	Topic: Chemical Addition

Instructor Notes:	Instructor Outline:
	Concentration x volume = concentration x volume $(N_1 \times V_1 = N_2 \times V_2)$
3. Feed rate usually has a unit value of gpm. Volume of chemical solution usually has unit value of gallons. Time usually has a unit value of minutes	3. Discuss and demonstrate how one calculates the feed rate of chemicals to a process stream so as to maintain a specific concentration using the formula: $\text{Feed Rate} = \dfrac{\text{volume of chemical solution}}{\text{Time}}$
	4. Give exercise problems.
	5. Review exercise problems.

CHEMICAL ADDITION

The ability to add chemicals to water or wastewater systems in the right quantities is a very important function of an operator.

The basis for the ability to calculate the amount of chemicals is

lbs = Conc. (mg/l) x 8.34 x Q

Where Q is the volume of the water in MG conc. (mg/l) is the desired concentration.

Example 1

How many pounds of chlorine is needed to make a 2 mg/l concentrated solution if the volume of water is 125,000 gallons.

$$\begin{aligned} \text{lbs.} &= \text{mg/l} \times 8.34 \times Q \\ &= 2 \times 8.34 \times .125 \\ &= 2.085 \text{ lbs.} \end{aligned}$$

One should remember that in the formula

$$\text{lbs.} = \text{mg/l} \times 8.34 \times Q$$

There are three VARIABLES and as long as one knows the values of two variables, the third one can be solved for

A. $\text{lbs.} = \text{mg/l} \times 8.34 \times Q$

B. $\text{mg/l} = \dfrac{\text{lbs.}}{8.34 \times Q}$

C. $Q = \dfrac{\text{lbs.}}{8.34 \times \text{mg/l}}$

At times the chemicals that are added may not be 100% pure or that it may not dissolve 100%, then one has to make adjustments for purity of the chemical.

Example

How many lbs. of HTH that contains 70% available Cl_2 is needed to make a 2 mg/l concentrated solution if the volume of water is 25,000 gallons.

Solution

Take note that it is the Cl_2 that is useful.

In solving the above problem one first calculates the needed lbs. of Cl_2

lbs. = mg/l x 8.34 x Q

= 2 x 8.34 x .125

= 2.085 lbs.

The Cl_2 needed is 2.085 lbs. which is obtained from the HTH. But the HTH only has 70% available Cl_2. Then,

70% = 2.085 lbs.

100% = ?

$\frac{2.085}{70}$ x 100 = 2.98 lbs. of HTH

In solving for problems pertaining to chemical addition one should realize that the primary effect that takes place when chemicals are added is that a chemical reaction may take place with other chemicals in the water before the main purpose for adding chemicals.

Example

When one adds Cl_2 for disinfection (main purpose) first a chemical reaction takes place. For example, with ammonia to make another chemical (mono - di - or tri chloramines). After the chemical reaction is complete then disinfection takes place with any extra Cl_2 left over.

The amount of chemical added is called the DOSE. The amount of chemical used in the chemical reaction is called the DEMAND. The amount of chemical left over is called the RESIDUAL.

Therefore

Dose = Demand + Residual

The flow from a plant is 125,000 gallons. Tests indicate that the chlorine demand is 1 mg/l and the residual is 1 mg/l. If you only need a 0.5 mg/l residual than how many pounds of Cl_2 is needed to achieve the 0.5 mg/l residual.

Solution

A. Dose = Demand + Residual

The need is Dose = 1 mg/l + 0.5 mg/l

= 1.5 mg/l

B. lbs. = mg/l x 8.34 x Q

= 1.5 x 8.34 x .125

= 1.56 lbs.

Example

You are to add fluoride to your water system. Tests indicate that fluoride present in the water system is 0.2 mg/l. How many pounds of fluoride is needed to make a 1 mg/l solution if the volume of water is 650,000 gallons.

A. Dose = Demand + Residual

1 mg/l = Demand + 0.2

Demand = 1 - 0.2

= 0.8 mg/l additional fluoride is needed

B. lbs. = mg/l x 8.34 x Q

= 0.8 x 8.34 x .65

= 4.34 lbs.

Exercise

1. A clear water well 45 ft. x 25 ft. x 15 ft. needs disinfection. The concentration should be 50 mg/l for proper disinfection. How many lbs. of Cl_2 is needed.
2. A 14" water main 2,000 ft. long needs to have Cl_2 added to a concentration of 60 mg/l. The only source of Cl_2 is 65% HTH. How many pounds of HTH is needed.
3. In the above problem (#2) how many pounds of HTH is necessary to give a 60 mg/l Cl_2 residual if the demand is 15 mg/l.
4. A water tank 1.25 MG needs to have a Cl_2 concentration raised from 0.1 to 0.5 mg/l. How many lbs. of 70% HTH is needed.
5. In a water system the F^- level is .4 mg/l and the required level of F^- is 1 mg/l. How many lbs. of F^- is needed if the pump is rated at 285 GPM and the total hours of operation is 14 hours.

In some cases one has to be able to change the concentration of a solution. The formula to use is a proportional formula.

$N_1 \times V_1 = N_2 \times V_2$

Where N_1 = Concentration of solution #1

V_1 = Volume of solution #1

N_2 = Concentration of solution #2

V_2 = Volume of solution #2

Example

Liquid chlorine (15% bleach) has a stock concentration of 150,000 mg/l of chlorine. How many gallons of the 15% bleach is needed to make a solution of 100 gallons of 2800 mg/l chlorine solution.

Solution

$N_1 \times V_1 = N_2 \times V_2$

$150{,}000 \times V_1 = 2800 \times 50$

$$V_1 = \frac{2500 \times 100}{150{,}000}$$

$= 1.67$ gallons

The formula $N_1 \times V_1 = N_2 \times V_2$ is a very useful formula that can be used both in the lab and in the plant.

Exercise

1. A container contains 30 gallons of 60 mg/l concentrated fluoride solution. You need to reduce the concentration to 42 mg/l. How many gallons of water should be added.
2. How many ML of 1.8 mg/l stock iodine solution is needed to make a 500 ml 0.0282 mg/l working solution.
3. How many ml of 1 normal (N) sodium thiosulfate solution is needed to make 250 ml of .025 N solution.

4. What is the concentration of 18 ml solution being standardized with 15 ml 0.025 N potassium BI-iodate.

5. Lab experiments indicate that the free chlorine residual in 2560 gal. tank is 4.8 mg/l. How many gallons of water should be wasted and then fresh water added to the tank if you need only a concentration of 0.5 mg of free chlorine.

Feed Rate

In determining the feed rate of a chemical solution the formula to use is:

$$\text{Feed Rate} = \frac{\text{Volume of solution}}{\text{Time}}$$

One should remember that there are many ways of dispersing chemicals to a process stream.

a. Slakers - dry feeders

b. Solution feeders

c. Slurry feeders

One can adjust the feed rate, or the concentration of solids in the feed solution.

Example

What is the feed rate of a chemical pump if the volume of solution prepared is 55 gallons and the pump operates for 15 hours.

Solution

$$\text{Feed rate} = \frac{\text{Volume of solution}}{\text{Time}}$$

$$= \frac{55 \text{ gal.}}{15 \text{ HR}}$$

$$= 3.67 \text{ GPH}$$

or

$$= 0.06 \text{ GPM}$$

Example

A chemical feeder has a rate of 10 ml per minute. What is the minimum gallon of solution (water) is needed if the feeder operates for 18 hrs. per day.

Solution

$$\text{Feed Rate} = \frac{\text{Volume of solution}}{\text{Time}}$$

Volume of solution = Feed rate x Time

= 10 ml/min. x 18 x 60

= 10500 ml

Convert 10800 ml to gallons

$$10800 \times \frac{1}{3750} = 2.88 \text{ gallons}$$

Exercise

1. Given:

   a. Feed pump rated at 40 ml/min.

   b. Water pump rated at 375 GPM

   c. Operating time 21 Hrs.

   d. Chlorine dose is 2.8 mg/l

   Calculate the minimum amount of HTH solution needed to satisfy the process.

2. A liquid feeder applies a 25% saturated sodium flouride solution to a water system raising the level from 0.2 to 1.0 mg/l of F-. At what rate should the feeder be set at if the water pump is rated at 218 GPM and the 25% saturated flouride solution provides 79% available fluoride. (Assume the pump operates continuously.)

Module No:	Module Title: Mathematics for Operators
	Submodule Title: Chemical Addition
Approx. Time: 1 hour	EVALUATION

Objectives:

The learner will demonstrate the ability to determine correctly the answers to 8 out of 10 problems related to chemical addition as applied to water and wastewater technology.

1. A water tower holds 0.85 million gallons. It needs to be disinfected with Cl_2 from 65% HTH to a concentration of 60 mg/l. Calculate the lbs. of HTH needed.

   a. 654.4 lbs.

   b. 425.3 lbs.

   c. 33.2 lbs.

   d. 276.5 lbs.

2. A 35 cm diameter water main 610 meters long needs to have a 75 mg/l concentration of Cl_2. How many kilograms of 70% HTH is used?

   a. 3.08 kilograms

   b. 6.16 kilograms

   c. 4.4 kilograms

   d. 1 kilogram

3. A treatment plant with a flow of 138,000 GPD uses 4 lbs. of Cl_2 per day. After 30 minutes contact time the free chlorine residual is 0.3 mg/l. Calculate the demand.

   a. 1 mg/l

   b. .59 mg/l

   c. 3.12 mg/l

   d. 2.32 mg/l

4. Given:

   a. Feed pump rate at 20 ml/min

   b. Water pump rated at 210 GPM

   c. Operating hours 14 Hrs.

   d. Fluoride concentration increased by 0.6 mg/l

   Calculate the lbs. of fluoride used.

   a. .04 lbs.

   b. 5.8 lbs.

   c. 1.5 lbs.

   d. 0.88 lbs.

5. A stock solution has a concentration of 45,000 mg/l. If the working solution is 40 gallons at 2800 mg/l calculate the volume of the stock solution.

   a. 4.0 gallons

   b. 2.49 gallons

   c. 37.51 gallons

   d. 36.00 gallons

6. In treating 235,000 gallons with 8.4 lbs. of Cl_2, calculate the dosage in mg/l.

   a. 8.4 mg/l

   b. 16.5 mg/l

   c. 0.23 mg/l

   d. 4.3 mg/l

7. A liquid feeder applies 3 gallons of 75% saturated sodium flouride solution to 500,000 gallons of water. What is the F- dose. The available fluoride is 45%.

   a. 3.9 mg/l

   b. 0.26 mg/l

   c. 1 mg/l

   d. .74 mg/l

8. Calculate the lbs. of alum needed to treat 812,000 gallons of water with a natural alkalinity of 195 mg/l to a concentration of 55 mg/l alkalinity (1 mg/l of alum induces alkalinity by 50%).

   a. 1320 lbs.

   b. 2640 lbs.

   c. 1896 lbs.

   d. 948 lbs.

9. Tests indicate that a 1 ml solution of 20 mg/l of coagulant added to 1000 ml of raw water provided the best results. How many lbs. of coagulant is needed to treat 1.3 million gallons.

   a. 216.8 lbs.

   b. 0.22 lbs.

   c. 2.17 lbs.

   d. 5 lbs.

10. A Cl_2 rotameter indicates a feed of 9.0 lbs/24 hrs. free residual test indicates a concentration of .5 mg/l in a flow of 365 GPM. Calculate the Cl_2 dose.

   a. 1.55 mg/l

   b. 2.05 mg/l

   c. 2.55 mg/l

   d. 1.0 mg/l

Module No:	Topic: EVALUATION
Instructor Notes:	Instructor Outline:
1. Handout Answers 1. c 2. a 3. c 4. d 5. b 6. d 7. b 8. c 9. b 10. b	1. Give 10 evaluation questions

Module No:	Module Title: Mathematics for Operators
	Submodule Title: Activated Sludge
Approx. Time: 1 hr.	Topic: Sludge Age

Objectives:

The learner will demonstrate the ability to determine the sludge age of solids in an activated sludge process.

Instructional Aids:

Handout

AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept. o
Env. Conservation.

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association.

Class Assignments:

Given 4 exercise problems to be solved.

Module No:	Topic: Sludge Age

Instructor Notes:

Handout

Refer to Module No._____

Submodule Title: Activated Sludge

Topic: Lbs. of solids under aeration

Refer to Module No._____

Submodule Title: Activated Sludge

Topic: Lbs. of solids under aeration.

Instructor Outline:

1. Discuss/demonstrate how one calculates for the sludge age using the formula:

   $$SA = \frac{\text{Lbs. of MLSS under aeration}}{\text{Organic loading}}$$

   SA = Sludge Age (Days)

   MLSS - Mixed liquor suspended solids

   a. Lbs. of MLSS under aeration is obtained by:

      Lbs. = Mg/l of MLSS x 8.34 x volume of aeration basin in (MG).

   b. Organic loading (Lbs/day) is obtained by:

      Lbs./Day = Mg/l of influent SS x 8.34 x Q to aeration basin

      Q = Flow rate of influent to aeration basin in MGD

2. Give 4 exercise problems.

ACTIVATED SLUDGE/SLUDGE AGE

Sludge age is a method for controlling the solids in an activated sludge process. The formula to use is

$$SA = \frac{\text{lbs. of MLSS under aeration}}{\text{Organic loading}}$$

SA = Sludge age

MLSS = Mixed liquor suspended solids

Organic loading = lbs. of influent suspended solids to the aeration basin

Example

Calculate the sludge age if

a. MLSS conc. is 2600

b. Volume of aeration basin 650,000 gallons

c. Primary effluent suspended solids 78 mg/l

d. Flow rate 3.5 MGD

Solution

$$SA = \frac{\text{lbs. of MLSS under aeration}}{\text{Organic loading}}$$

lbs. of MLSS under aeration = MLSS conc. x 8.34 x Vol. of aeration basin

lbs. of MLSS under aeration = 2600 x 8.34 x .65

= 14095 lbs.

Organic loading = S.S. conc. x 8.34 x Q

= 78 x 8.34 x 3.5

= 2277 lbs.

$$SA = \frac{2600 \times 8.34 \times .65}{78 \times 8.34 \times 3.5}$$

= 6.2 days

Exercise

1. Calculate the sludge age if

   a. Aeration basin dimensions length 85 ft., width 37 ft., depth 20 ft.

   b. Primary effluent suspended solids 110 mg/l

   c. Flow rate 1,540,000 GPD

   d. MLSS conc. 1800 mg/l

2. Calculate the sludge age of the solids in an activated sludge process if 13,000 lbs. of solids are under aeration and 3050 lbs. per day is being introduced to aeration.

3. Given:

   a. MLSS 3200 mg/l

   b. Aeration basin radius 20 ft., height 14 ft.

   c. Influent suspended solids 195

   d. Flow rate 438,522 gallons/day

   Calculate sludge age

4. Calculate the sludge age of the solids in an activated sludge process if 65,000 lbs. of solids are under aeration and the influent suspended solids is 245 mg/l in concentration and a flow of 5.3 MGD.

   lb. = mg/l x 8.34 x q

   $$\text{mg/l} = \frac{\text{lbs.}}{8.34 \times Q}$$

Module No:	Module Title: Mathematics for Operators
	Submodule Title: Activated Sludge
Approx. Time: 1 hr.	Topic: Mean Cell Retention Time (MCRT)

Objectives:

The learner will demonstrate the ability to determine the mean cell retention time (MCRT) in an activated sludge process.

Instructional Aids:

Handout

AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept of Env. Conservation.

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association.

Class Assignments:

Given 4 exercise problems to be solved.

Module No:

Topic: Mean Cell Retention Time (MCRT)

Instructor Notes:

Handout

Refer to Module No. _____

Submodule Title Weights (Pounds)

Topic: Conversion

Refer to Module No. _____

Submodule Title Weights (Pounds)

Topic: Conversion

Instructor Outline:

1. Discuss and demonstrate how one calculates the MCRT in an activated sludge process using the formula:

   $$\text{MCRT} = \frac{\text{Lbs. of MLSS in total volume of system}}{\text{Lbs. of solids removed from process}}$$

   MCRT = Mean cell retention time in (days)

   Lbs. of MLSS = Mg/l of MLSS x 8.34 x V

   V = Total volume of aeration basin + clarifier in (MG)

   Lbs. of solids removed from process = Lbs. of sludge wasted + Lbs. of SS in clarifier effluent.

2. Give 4 exercise problems.

ACTIVATED SLUDGE/MEAN CELL RETENTION TIME

Calculating for mean cell retention time (MCRT) one uses the formula

$$\text{MCRT} = \frac{\text{Lbs. of MLSS in total system}}{\text{Lbs. of solids removed from process}}$$

Lbs. of MLSS in total system is determined by:

Concentration of MLSS x 8.34 x (Volume of aeration basin + volume of clarifier)

Note: Remember that volume is in million gallons.

Lbs. of solids removed from process is determined by:

1. The lbs. of suspended solids in clarifier effluent.
2. The lbs. of solids wasted.

Example

Calculate the MCRT if:

a. Aeration basin volume = 438,500 gallons

b. Clarifier volume = 220,000 gallons

c. Flow rate to process = 2 MGD

d. Sludge wasted = 0.35 MGD

e. MLSS = 2,200 mg/l

f. Return activated sludge = 6,300 mg/l

g. Final effluent suspended solids = 12 mg/l

Solution

$$\text{MCRT} = \frac{\text{lbs. of MLSS in total volume of system}}{\text{lbs. of solids removed from process}}$$

$$\text{MCRT} = \frac{2{,}200 \times 8.34\ (.4385 + .22)}{6{,}300 \times 8.34 \times .035 + 12 \times 8.34 \times 2}$$

$$= \frac{12{,}082.2}{2{,}039.1}$$

$$= 5.93 \text{ days}$$

Exercise

1. Calculate the MCRT if
   a. Aerator volume = 1.5 MG
   b. Clarifier volume = .7 MG
   c. Flow rate to plant = 4.95 MGD
   d. MLSS = 1,900 mg/l
   e. Return activated sludge = 6,500 mg/l
   f. Effluent S.S. = 31 mg/l
   g. RAS rate = .1 MGD
2. Given:
   a. Aeration basin radius 22 ft., height 15 ft.
   b. Clarifier basin radius 12 ft., height 12 ft.
   c. MLSS = 1,800 mg/l
   d. Influent flow rate = 5 GPS
   e. RAS = 6,000 mg/l
   f. Effluent S. S. = 23 mg/l
   g. RAS rate = .005 MGD

   Calculate MCRT
3. Given:
   a. MCRT = 6 days
   b. Total volume = 1.2 MG
   c. MLSS = 3,100 mg/l
   d. Influent flow rate = .5 MGD
   e. Effluent S. S. = 65 mg/l
   f. RAS = 6,200 mg/l

   Calculate the RAS wasted volume.

4. In Problem 3 calculate the rate of RAS wasted in (MGD) if the MCRT should be 7 days.

Module No:	**Module Title:** Mathematics for Operators
	Submodule Title: Activated Sludge
Approx. Time: 1 hr.	**Topic:** Food - Microorganism Ratio (F/M)

Objectives:

The learner will demonstrate the ability to determine the food/microorganism ration (FM) using:

1. BOD as source of food
2. COD as source of food

Instructional Aids:

Handout

AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept. of Env. Conservation.

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association.

Class Assignments:

Given 4 exercise problems to be solved.

Module No:	Topic: Food/Microorganisms Ratio (F/M)
Instructor Notes:	**Instructor Outline:**
1. Handout a. Refer to Module No.____ Submodule title: Activated Sludge Topic: Organic Loading b. Refer to Module No.____ Submodule Title: Weights (Pounds) Topic: Conversion	1. Discuss/demonstrate how one calculates the F/M ratio. $FM = \frac{\text{Lbs. of food in influent to aeration Basin}}{\text{Lbs. of MLVSS under aeration}}$ FM = Lbs./day/1 Lb. of MLVSS MLVSS = Mixed liquor volatile suspended solids Lbs. of food in influent to aeration basin is either: 1. Lbs. of BOD or 2. Lbs. of COD Lbs/day = Mg/l x 8.34 x Q (MGD) MLVSS in Mg/l is obtained from lab results (volatile solids of suspended solids).
	2. Give 4 exercise problems 2 - Using BOD 2 - Using COD

ACTIVATED SLUDGE/FOOD MICROORGANISM RATIO

Food/Microorganism Ration (F/M) is calculated by using the formula

$$F/M = \frac{\text{Lbs. of influent food applied to aeration basin}}{\text{Lbs. of MLVSS under aeration}}$$

Lbs. of influent food applied to aeration basin is based upon

a. Lbs. of BOD or

b. Lbs. of COD

Lbs. of MLVSS under aeration is the lbs. of mixed liquor volatile suspended solids.

F/M is reported in lbs/day/1 lb. of MLVSS

Example

Calculate the F/M Ratio if the COD is 160 mg/l, the influent flow rate is .655 MGD, the lbs. of MLVSS is 1,700 lbs.

Solution

$$F/M = \frac{\text{lbs. of COD}}{\text{lbs. of MLVSS}}$$

$$= \frac{160 \times 8.34 \times .655}{1{,}700}$$

$$= 0.514 \text{ lbs. of COD/day/1 lb. of MLVSS}$$

Exercise

1. Given

   a. Aeration basin - Radius 32 ft., height 10 ft.

   b. MLVSS - 2,400 mg/l

   c. COD - 216 mg/l

   d. Influent flow rate - .8 MGD

   Calculate the F/M Ratio

2. Given

   a. Aeration Basin - Length 38 ft., width 21 ft., height 13 ft.

   b. F/M Ratio of 0.5 lbs. of BOD/day/1 lb of MLVSS

   c. BOD - 1 lb. mg/l

   d. Influent flow rate 1.2 MGD

   Calculate the MLVSS concentration

3. Given

   a. Aeration basin - diameter 70 ft., height 12 ft.

   b. MLVSS - 2,050 mg/l

   c. COD - 115 mg/l

   d. Influent flow rate - .7 MGD

   Calculate the F/M Ratio

4. Given

   a. Aeration basin - Length 45 ft., width 18 ft., height 11 ft.

   b. MLSS - 2500 mg/l

   c. COD - 130 mg/l

   d. Influent flow rate - 935,000 GPD

   e. MLVSS is 78% of MLSS

   Calculate the F/M Ratio

Module No:	Module Title: Mathematics for Operators
	Submodule Title: Activated Sludge
Approx. Time: ½ hr.	Topic: Return Activated Sludge Rate

Objectives:

The learner will demonstrate the ability to determine the return activated sludge rate as:

1. Gallons per day
2. Percent of influent flow

Instructional Aids:

Handout

AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept. of Env. Conservation.

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association.

Class Assignments:

Given 4 exercise problems to be solved.

Module No:

Topic: Return Activated Sludge Rate (RAS)

Instructor Notes:

1. Handout
   a. Explain combined flow
   b. Explain influent flow

Instructor Outline:

1. Discuss/demonstrate how one calculates the return activated sludge rate using the formula

   RAS = Combined flow - Influent flow

   Combined flow = The flow added to the aeration basin composed of influent flow + return activated sludge

   Influent flow = The flow rate that pumped to the treatment plant

2. Discuss/demonstrate how one calculates the return activated sludge rate as % of influent flow using the formula

   $$\%RAS = \frac{\text{Comb. flow} - \text{Inf. flow}}{\text{Inf. flow}} \times 100$$

   %RAS = Percent return activated sludge rate

   Comb. flow = Combined flow rate added to the aeration basin composed of influent flow rate + return activated sludge rate

   Inf. flow = Influent flow rate to plant

3. Give 4 exercise problems

ACTIVATED SLUDGE/RETURN ACTIVATED SLUDGE RATE

Return activated sludge rate (RAS) is calculated by using the formula

RAS = combined flow - influent flow

Combined flow is the sum of all the flow added to the aeration basin.

Influent flow is the flow from the primary system or the plant influent.

Example

The flow rate to the aeration tank is .568 MGD and the flow rate to the plant is .426 MGD. Calculate the RAS.

Solution

RAS = combined - influent

= .568 - .426

= .142 MGD

The RAS is usually reported as % flow of the influent rate. The formula to use is

$$\% \text{ RAS} = \frac{\text{RAS} \times 100}{\text{Influent Flow Rate}}$$

Example

What is the % RAS if the influent flow rate is .426 MGD and the RAS is .142 MGD.

Solution

$$\% \text{ RAS} = \frac{\text{RAS} \times 100}{\text{Influent flow rate}}$$

$$= \frac{.142 \times 100}{.426}$$

$$= 33.33\%$$

Exercise

1. Given the flow rate to the plant at 500 GPM, calculate the % RAS if the rate of return activated sludge is 105 GPM.

2. The flow rate to the aeration basin is 1.8 MGD. If the influent flow rate is 1.5 MGD, calculate the % RAS.

3. The % RAS is 22% of the influent flow rate, .935 MGD, calculate the combined flow rate to the aeration basin.

4. The % RAS is 25% of 435,000 GPD influent flow rate. Calculate the RAS flow rate in GPM.

Module No:	Module Title: Mathematics for Operators
	Submodule Title: Activated Sludge
Approx. Time: 1 hr.	Topic: Sludge Volume Index (SVI)

Objectives:

The learner will demonstrate the ability to determine the sludge volume index in an activated sludge process.

Instructional Aids:

Handout

AV (overhead transparancy)

Instructional Approach:

Discussion
Demonstration
Exercise

References:

Workbook, Basic Mathematics and Wastewater, Processing Calculations, N. Y. Dept. of Env. Conservation.

Study Aid Workbook, Mathematics for Wastewater Treatment Plant Operators, California Water Pollution Control Association.

Class Assignments:

Give 4 exercise problems to be solved.

Module No:	Topic: Sludge Volume Index (SVI)

Instructor Notes:

1. Handout

Instructor Outline:

1. Discuss/demonstrate how one calculates the sludge volume index (SVI)

   The formula is:

   $$SVI = \frac{\text{Volume of MLSS in a 1000 ml. sample}}{\text{Concentration of MLSS}} \times 100$$

   SVI = Sludge volume index

   Volume (ml) of MLSS in a 1000ml. sample obtained from lab test.

   Concentration of MLSS = mg/l of mixed liquor suspended solids

2. Give 4 exercise problems.

ACTIVATED SLUDGE/SLUDGE VOLUME INDEX

Sludge volume index (SVI) is calculated by using the formula

$$SVI = \frac{\text{Volume of MLSS/1000 ml sludge sample} \times 1000}{\text{Concentration of MLSS}}$$

Volume of MLSS/1000 ml sludge sample is obtained by placing 1000 ml of activated sludge in a 1000 ml graduated cylinder letting the solids settle for 30 minutes. The volume of solids is the volume of MLSS/1000 ml sludge sample.

Example

The conc. of MLSS is 2,500 mg/l and the lab test indicates a 250 ml volume. Calculate SVI.

Solution

$$SVI = \frac{\text{Vol. of MLSS/1000 ml}}{\text{Conc. of MLSS}} \times 1{,}000$$

$$= \frac{250}{2500} \times 1{,}000$$

$$= 1{,}000$$

Exercise

1. Calculate the SVI if the lab tests indicate a volume of 350/1000 ml and a MLSS concentration of 2,100 mg/l.

2. Calculate the concentration of the MLSS if the SVI is 0.12 and the settling test indicates a volume of 190 ml/1000 ml.

3. Calculate the SVI if the solids in a 1000 ml MLSS sample settle to 450 ml and the MLSS concentration is 2,800 ml.

4. How many mg/l of MLSS should be wasted if the MLSS conc. is 2,800, and the settle solids is 300 mg/l but the desired SVI is 0.1.

Module No:	Module Title: Mathematics for Operators
	Submodule Title: Activated Sludge
Approx. Time: 1 Hour	EVALUATION

Objectives:

The learner will demonstrate the ability to determine correctly the answers to 8 out of 10 problems related to activated sludge process.

a. Sludge Age

b. Mean cell retention time

c. Food/Microorganism Ratio

d. Return Activated Sludge Rate

e. Sludge Volume Index

1. Calculate the sludge age in an activated sludge process if 23,500 lbs. of solids are under aeration and 5,850 lbs/day of solids are being introduced to the aeration basin with a volume of 1.3 MGD.

   a. 5 days

   b. 3.09 days

   c. 0.3 days

   d. 4 days

2. Calculate the sludge age of the solids in an activated sludge process if 45,000 lbs are under aeration and the influent suspended solids are 125 mg/l in concentration and a flow of 3.2 MGD.

   a. 11.5 days

   b. 7 days

   c. 13.5 days

   d. 0.07 days

3. Calculate the required lbs. of MLSS in an aeration basin if the desired sludge age is 6.5 days. The lbs. of solids applied to the aeration basin is 1,755 lbs/day.

   a. 3,703.7 lbs.

   b. 11,407.5 lbs.

   c. 270 lbs.

   d. 2,251.8 lbs.

4. Given

   Aeration basin - 40 ft. radius, 11 ft. height

   MLVSS - 2,100 mg/l

   COD - 154 mg/l

   Influent Rate - .935 MGD

   Calculate the F/M Ratio

   a. 0.17 lbs of COD/day/lb. of MLVSS

   b. 0.09 lbs. of COD/day/lb. of MLVSS

   c. 5.8 lbs. of COD/day/lb. of MLVSS

   d. 4.0 lbs. of COD/day/l of MLVSS

5. Given

   Aeration basin - 35 ft. radius, 12 ft. height

   MLVSS - 1,960 mg/l

   COD - 125 mg/l

   Influent rate - 1.2 MGD

   MLSS - 2,800 mg/l

   Desired F/M Ratio - 0.3 lbs/COD/day/lb. MLVSS

   $\frac{\text{MLVSS}}{\text{MLSS}} = 70\%$

   Calculate the lbs. of MLSS needed to be wasted.

a. 2,100 lbs.

b. 4,169 lbs.

c. 1,500 lbs.

d. 200 lbs.

6. The flow rate to the aeration basin is .873 MGD and the influent flow rate to the plant is .863 MGD. Calculate the % return activated sludge rate.

a. 98.8%

b. 1.2%

c. 25%

d. 38%

The information given is to be used in Problem 7, 8, 9, & 10.

Given

Aeration basin volume = 0.3 MG

Clarifier volume = 0.2 MG

MLSS = 2,900 mg/l

MLVSS content = 75% of MLSS

Settleable solids test = 360 mg/1,000 ml.

Primary effluent BOD = 152 mg/l

Primary effluent suspended solids = 90 mg/l

Influent flow rate = 1.8 MGD

% RAW flow rate = 20%

7. Using the above information calculate sludge age.

a. 5.3

b. 6.4

c. 3.2

d. 5.3

8. Using the above information, calculate the SVI.

    a. 100

    b. 81

    c. 124

    d. 35

9. Using the above information, calculate the F/M Ratio (lbs. BOD/day/ lb. MLVSS)

    a. .419 lbs. of BOD/day/lbs. MLVSS

    b. 2.4 lbs. of BOD/day/lbs. MLVSS

    c. 0.31 lbs. of BOD/day/lbs. MLVSS

    d. 1 lb. of BOD/day/lb. MLVSS

10. Using the above information, calculate the lbs. of MLSS wasted to provide a desired sludge age of 5 days.

    a. 1,351 lbs.

    b. 500 lbs.

    c. 800 lbs.

    d. 100 lbs.

Module No:	Topic: EVALUATION

Instructor Notes:	Instructor Outline:
1. Handout	Give 10 evaluation problems.
2. Ans.	

1. d
2. c
3. b
4. a
5. a
6. b
7. d
8. c
9. a
10. b